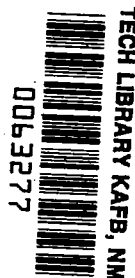


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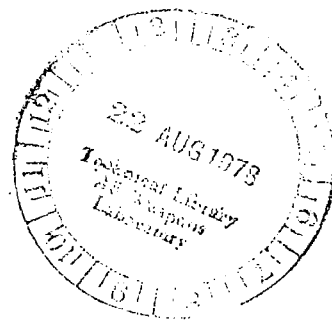
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## Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for July 1974 Through June 1976

JUNE 1978





NASA Reference Publication 1023

Synoptic Analyses, 5-, 2-,  
and 0.4-Millibar Surfaces  
for July 1974 Through June 1976

*Prepared by Staff, Upper Air Branch  
National Weather Service  
Camp Spring, Maryland  
under NASA Wallops Flight Center  
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for NASA Wallops Flight Center*



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and Space Administration

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# SYNOPTIC ANALYSES, 5-, 2-, AND 0.4-MILLIBAR SURFACES,

FOR JULY 1974 THROUGH JUNE 1976

by Staff,<sup>1</sup> Upper Air Branch.

NOAA, National Weather Service, National Meteorological Center

## SUMMARY

Meteorological rocketsonde and satellite radiance data have been employed for analyses of a continuing series of high-altitude constant-pressure charts. The methods of processing, the various types of data utilized and the analysis procedure are described.

Broad-scale analyses of temperature and geopotential height for the Northern Hemisphere 5-, 2-, and 0.4-mb surfaces are presented for each week of the period July 1974 through June 1976.

Brief discussions of the variations of the temperature and height fields throughout the two-year period are also given.

## INTRODUCTION

This report is the eighth in a series of constant-pressure charts for the upper stratosphere and lower mesosphere. Previously, charts for 1964-68 (refs. 1, 2, 3, 4, and 5) were analyzed at weekly intervals and were based primarily on meteorological rocketsonde data obtained throughout North America and adjacent ocean areas (refs. 6 and 7). Since 1972 it has been

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<sup>1</sup>Personnel actively engaged in this project were: Manager, F. G. Finger; Coordinator and Analyst, M. E. Gelman; Analyst, L. J. Hortch; Systems Developers, R. M. Nagatani and J. D. Laver; Research Consultants, R. S. Quiroz and A. J. Miller; and data processing, D. L. Griffith and J. D. Kopman.

possible to extend the analyses to most of the Northern Hemisphere (refs. 8, 9, and 10). Figure 14 shows the locations of the 20 meteorological rocket launch sites for which data were available.

Data from satellite vertical temperature sounding instruments have been used since 1972 (see section on satellite data, below). The use of satellite information, together with in situ rocket observations, results in greatly improved data coverage over the entire hemisphere.

This series of weekly analyses of the 5-, 2-, and 0.4-mb surfaces (approximately 36, 42, and 55 km, respectively) portrays the broad-scale synoptic conditions over the Northern Hemisphere during July 1974 through June 1976. Charts are presented for each Wednesday during that period, except for July and August 1974 when only 3 of the 9 Wednesday charts were prepared. Relatively small-scale time and space changes (refs. 11 and 12) are observed during summer, but the horizontal resolution of the analyses in most areas has, in the past, not been sufficient to depict them. The increased availability of satellite data, however, is making the analysis of smaller-scale features more plausible. Thus, weekly summer charts have been provided since 1975.

During winter and the transition periods, large changes may be evident from one week to the next. Sometimes, these variations occur within a day or two and may be inferred from the sequence of up to three observations plotted at each rocket station. Thus, the user may enhance the utility of the weekly charts by noting any large changes during the week in plotted temperature or wind direction, and inferring movement of the synoptic systems depicted in the Wednesday charts.

Despite the omission of the smaller-scale details, the maps are very useful for a number of applications. Examples include determining the trajectory of constant-level balloons, relating variations in infrasound propagation to circulation changes, and providing a data base (climatological and synoptic) for evaluating environmental effects on aerospace vehicles. In addition, users have pointed to the increasing utility of these maps for studies of stratospheric-ionospheric interaction, for verification of the performance of numerical circulation models, and for various other research efforts.

## PROCESSING OF ROCKETSONDE DATA

Temperature, height, and wind information derived from routine meteorological rocketsonde observations comprise the basic data for analyses at the 5-, 2-, and 0.4-mb levels. Rocketsonde information used for this project were obtained from teletype coded ROCOB messages (WMO code FM39.E ROCOB and FM40.E ROCOB ship). These data are usually transmitted from each rocketsonde station within one day of observation. Data from Heiss Island, Volgograd, and Thumba and certain ships are available in ROCOB format within one week of observation time.

The ROCOB message generally provides data in the form of temperature and wind versus geometric height. In these cases, the vertical coordinate must be transformed from height to pressure so that temperature, height, and wind information may be extracted at the desired pressure levels.

A variety of problems may restrict the accuracy of measured temperatures at the higher rocketsonde levels. Thus, in most cases correction systems have been derived by theoretical or laboratory methods. For the U.S. Datasonde System, the most recent temperature correction scheme (ref. 13) considers aerodynamic heating (which depends mainly on the fall velocity of the sensor), thermal lag, emitted and absorbed radiation, and electrical heating. Corrections based on these factors were generally applied to U.S. ROCOB data for this period (ref. 14).

International (WMO-sponsored) rocketsonde intercomparisons have shown (ref. 15) large differences between temperatures reported from U.S. and U.S.S.R. soundings, even after each set of data has been "corrected" according to latest theoretical and laboratory results. For this reason further adjustments to temperatures reported in ROCOB messages were applied to U.S.S.R. data. Reported U.S.S.R. ROCOB temperatures were raised by amounts of 2°C at 50 km, 7°C at 55 km, and 9°C at 58 km, as recommended in ref. 15.

The partially computerized procedure for calculating pressure and extracting the required information for the 5-, 2-, and 0.4-mb levels was as follows:

- a. Pressure was calculated at each ROCOB reported level by integrating the hydrostatic equation starting at a base level near 50 mb. Temperature and height data obtained from a nearby rawinsonde station were used as the reference-level data. The geopotential heights and temperatures at the 5-, 2-, and 0.4-mb levels were then interpolated.

b. Wind direction and wind speed were interpolated manually at the calculated height of each analysis level. When temperature data were not available for a particular sounding, the wind information was extracted at individually estimated heights of the 5-, 2-, and 0.4-mb levels.

c. Time-height diagrams were plotted for each rocketsonde station. The temperature and wind information on these diagrams provided valuable verification of the sequence of meteorological changes. In addition, erroneous or questionable data could be quickly isolated.

d. From the wind information plotted on the time-height diagrams, thermal winds were determined for approximately 6-km layers centered on each analysis level. Although at times there were rapid wind oscillations with height, an unambiguous direction for the thermal wind could usually be determined.

#### PLOTTING OF DATA

The rocketsonde data--temperature ( $^{\circ}\text{C}$ ), height (geopotential meters) and wind direction and speed (knots)--were plotted on a polar stereographic map base. On the charts presented for publication, three available observations closest to Wednesday are shown for each station. Reported heights and calculated thermal winds have been omitted for the sake of legibility. The station model chart (Fig. 14) illustrates the symbols used to distinguish data obtained on Wednesdays from off-time data.

#### USE OF SATELLITE DATA

Data from the NOAA 3 and 4 Vertical Temperature Profile Radiometers (VTPR) (ref. 16) and the Nimbus 5 Selective Chopper Radiometer (SCR) (ref. 17) were used in deriving the 1974-76 height and temperature fields.

The method of using the remotely sensed temperature information for determining stratospheric thickness is given in ref. 18. In brief, the radiant energy sensed by a satellite instrument in any spectral band is representative of the weighted temperature from a substantial layer in the atmosphere. Relationships were derived relating satellite-measured radiances and the radiosonde-rocketsonde computed thickness (or mean temperature) between the 100- to 5-mb, 100- to 2-mb, and 10- to 0.4-mb levels. The regression relationships used for the charts from

July 1974 to August 1975 are illustrated in Figure 1. The relationships between satellite-measured radiances and radiosonde-rocketsonde thicknesses were used as an aid in constructing the analyses in the following manner:

- a. Hemispheric radiance fields containing 24 hours of satellite data were analyzed.
- b. Radiance isopleths were converted to thickness isopleths by the use of the radiance-thickness relationships.
- c. The thickness field was then added to the objectively analyzed height field of a base chart; either an analyzed chart for 100 mb (ref. 19) for build-up to 5 or 2 mb, or a 10-mb chart for build-up to 0.4 mb.

The first-approximation charts for September 1975 to June 1976 were derived totally by computer. As an initial step, VTPR channel 1 (I1) and channel 2 (I2) radiances were objectively analyzed. Regression relationships of radiance versus thickness listed in Table 1 were then used to convert the appropriate analyzed fields of radiance to the respective thickness fields. Each first-guess chart was thus constructed by adding the thickness fields to the appropriate base charts as indicated in c above.

TABLE 1

Regression Relationships*		R	SE
Thickness			
100-5 mb	$10877 + 261.2(I2) - 1.646(I2)^2$	0.959	257 m
100-2 mb	$13915 + 295.5(I1) - 1.418(I2)^2$	0.977	287 m
10-0.4 mb	$16022 + 311.3(I1) - 219.2(I2)$	0.968	392 m
Temperature			
at 5 mb	$-171.6 + 3.205(I1) - 0.0206(I2)^2$	0.931	6.9 C
at 2 mb	$-120.9 + 4.51(I1) - 3.301(I2)$	0.945	7.4 C
at 0.4 mb	$16.13 + 1.457(I1) - 0.00285(I2)^2 - 3.728(I2) + 0.03(I2)^2$	0.48	10.3 C

R, correlation coefficient; SE, standard error of estimate.

\*Regression relationships derived from 106 coincident rocketsonde/radiosonde-VTPR soundings.

Relationships between radiance and temperature at 5, 2, and 0.4 mb were also sought. A weaker physical relationship exists between radiance and the temperature at any particular level than exists between radiance and the mean layer temperature or thickness. However, it had been found that SCR channel 1 and SCR channel 2 specified the temperature at 5 and 2 mb to a good approximation (RMS error, approximately 6 to 8°C). The relationships shown in Fig. 1 were used for the charts of July 1974 to August 1975. The temperature patterns obtained by relabeling the appropriate SCR radiance charts were then used as a first guess in deriving the 5- and 2-mb temperature analyses. Subsequently, it was determined that comparable results could be obtained by the use of VTPR stratospheric channels (ref. 20). Thus the temperature fields of September 1975 to June 1976 were derived by computer methods using the VTPR regression relationships listed in Table 1.

#### ANALYSIS PROCEDURE

The analysis procedure consisted in obtaining first-approximation temperature and height fields and then manually adjusting these fields to conform with the rocketsonde wind, height, temperature, and thermal-wind information. First-approximation fields were obtained using the methods discussed in the previous section.

The analysis systems consisted of the following steps:

a. Isotherms were approximated initially from plotted rocketsonde temperatures. Data acquired for each entire week were examined to determine the synoptic changes that took place during that week. Thus, conditions prevailing on Wednesday--the analysis day--were deduced. The satellite-determined first approximations to the temperature fields at 5 and 2 mb were especially useful in providing an overall framework for further adjustment toward data provided by rocket observations. Computed thermal winds were also very useful, especially for determining horizontal temperature gradients and the relative location of warm and cold areas. Time-height sections of temperature were consulted as a further aid in deriving the isotherms.

b. Reported winds and computed heights for individual stations were employed to adjust the first approximation of the contour field, assuming geostrophic flow. Winds were accorded the highest priority for this adjustment. When large adjustments were made to the contour field, the temperature field was necessarily adjusted to maintain hydrostatic consistency.

c. The analyses were reviewed for vertical and temporal consistency. For example, circulation centers, ridges, and troughs were examined with the aid of all available data to verify vertical slope and movement with time. Checks of hydrostatic consistency were also made for each series of charts.

The above procedures, primarily those including the use of satellite data produced good results at 5 mb and 2 mb, and were successfully applied to obtain the 0.4-mb charts. Generally, the adjustments to the first-approximation height fields by the addition of rocket data at the 5- and 2-mb levels were not large. Because of the lack of first approximation fields for 0.4-mb temperature more formidable analysis problems were evident at the 0.4-mb level.

Another difficulty was the apparent occurrence of large day-to-day temperature changes, at times exceeding  $10^{\circ}\text{C}$  (ref. 21), and persistent oscillations in many wind profiles. In most cases, deviations of reported temperatures and winds from one another could be accounted for by identifiable rapid large-scale synoptic changes. Sometimes rocketsonde reports within a few hours of each other at a single station exhibited temperature changes of  $5^{\circ}$  to  $7^{\circ}\text{C}$  over a limited height interval near the stratopause. It has been shown that such small-scale changes are possible at these levels (ref. 22). Thus, some intermediate value was chosen for analysis to represent the value on the analysis day. Occasionally, it was impossible to make a reasonable reconciliation of reported station values.

Although careful consideration of high-level data allows a broadscale depiction of circulation patterns up to 0.4 mb, the sparsity of reports requires increasing subjectivity as the analysis proceeds to this level. The justification for some analyses depends on the interpretation of the limited amount of data in such a way as to portray a coherent sequence of synoptic events. In spite of these factors, surprisingly little alteration in the principal features of the circulation and temperature distribution shown in the final analysis can be made without inordinately violating some of the data. In general, the contours and isotherms depicted are felt to be good approximations to the flow and temperature patterns at this level. Even so, the same degree of accuracy that is found customarily in the analysis of charts at lower levels should not be expected.

A contour interval of 320 geopotential meters was used throughout the year. In addition, intermediate dashed contours were used to outline areas of relatively weak gradient, especially during the spring and fall changeover periods. Isotherms were drawn and labeled at  $5^{\circ}\text{C}$  intervals.



## DISCUSSION OF THE JULY 1974 - JUNE 1976 CIRCULATION

### Introduction

The publication of two years of charts in one booklet provides the opportunity to compare directly the circulation features during these years. Thus, in addition to describing the large-scale circulation features for the period, we will point out briefly the major differences and similarities between the circulation for given seasons. The reader may use these as examples from which to study, in further detail from these charts, the Northern Hemisphere circulation in the higher stratosphere and lower mesosphere.

### Summer-Autumn Circulations

During summertime the relatively stable polar anticyclone and associated easterlies reflect increased solar absorption in high latitudes. Maximum temperatures occur near the North Pole with generally decreasing values toward middle and low latitudes. From the charts available (and from other information not shown) it is clear that maximum summertime temperatures occurred in mid-July during both years. Associated with this temperature maximum is the strongest easterly flow. A close inspection of the data reveals that small-scale changes do indeed take place throughout the area covered by the anticyclone. These daily changes, however, cannot be properly delineated by this type of synoptic analysis, which is severely restricted by the number of observations available.

Significant differences in the large-scale circulation between the two years become apparent on the charts for August. Although westerly winds first appeared at the 0.4-mb level on August 7, 1974, they were not discernible in 1975 until August 20. During the latter year, relatively warm air was evident in the polar regions until well into August, and the lowest temperatures at 0.4 mb occurred at mid-latitudes. This temperature differential was associated with the developing tropical westerlies.

From late August to early September of both years the polar westerlies became increasingly evident at the various levels. As these westerlies intensified throughout September, the anticyclonic easterlies, located on the southern side of a semi-continuous ridge, moved southward to mid latitudes. Although

the sequence of transformations from easterly to westerly circulation was not reproduced exactly in these two years (nor any two years, as seen from the full series of these charts beginning in 1964) the overall sequence of events was quite comparable.

Whereas the summer and autumn large-scale circulation patterns were quite similar during the years 1974 and 1975 there were significant differences between the character of the winters of 1974-75 and 1975-76. Additionally there were large differences in the sequence of spring circulation reversals of the two years. The sequence of events will be discussed separately for each year and then they will be compared.

#### Autumn 1974

During most of the 1974 autumn period, polar-region temperatures in the middle stratosphere (5- and 2-mb charts) were relatively low with respect to those at lower latitudes. At 0.4 mb, however, a pronounced region of warm air extended over the Pole during most of October 1974. This warm air initially covered the polar Siberian region, but by November 13, 1974, the entire area north of the Arctic circle was dominated by relatively high temperatures. Perturbations at all the higher stratospheric levels were evident during November. Of particular interest is the tendency for anticyclonic circulation over northern North America associated with a movement of the polar cyclone southward. A return to more stable cyclonic flow occurred at all levels by early December.

#### Winter 1974-75

Another important perturbation in the 0.4-mb temperature field occurred over the polar Siberian region on December 11, 1974. During the following several weeks developments at lower levels led to a significant stratospheric warming. The extent of warming and circulation change at upper stratospheric levels may be seen by comparing the charts for December 25, 1974 with those of the following week, January 1, 1975. During this period warming by more than 40 degrees C occurred over the Pole in connection with the northward movement and intensification of the warm center over Eurasia. The accompanying circulation changes were equally dramatic. At 2 and 0.4 mb on January 1, 1975, easterlies dominated much of the polar circulation. This

strong wind field was associated with an intensifying anticyclone centered over the Alaska-Siberian Arctic. Some further northward movement of the easterlies occurred during the following 2 weeks in the upper stratosphere, but at 5 mb and below (as indicated by daily charts at 10, 30, 50, and 70 mb), the basic westerly flow remained dominant. It is difficult to classify the intensity of warmings purely objectively, since they occur in many different manners. In the past, however, major phenomena of this type have affected nearly the entire stratosphere (down to about 100 mb). Since this particular warming was confined to the higher levels and resulted in only a short-term circulation change it should be classified a relatively minor event. Even so, at levels above 5 mb, the event had considerable impact. It was indeed the most significant perturbation of the 1974-75 mid-winter period. Further details of warming activity during this winter are given in ref. 23.

The charts indicate that by January 22, 1975 the westerly vortex had returned to its polar position, although somewhat weaker in intensity than it had been previous to the warming episode. During the next month the cyclone slowly deepened and regained some of the strong westerly circulation evident before the stratospheric warming. However, in mid-February the polar vortex once again began to fill. This process was associated with a strong thermal oscillation beginning after mid-February, shown by VTPR radiance data (ref. 23).

### Spring 1975

By March 5, 1975 a strong anticyclonic system had developed over Eurasia. The complex manner of development in succeeding weeks makes it uncertain as to whether this is the same system leading to the final springtime circulation reversal. This reversal was not fully apparent until 2 months later (in the first week of May 1975). The change from the westerlies of February to the easterlies of May was not continuous since a westerly-type circulation was temporarily reestablished at 2 and 0.4 mb on April 2. We may therefore view the events in February-March as a late winter perturbation, distinguishable from the final springtime warming and circulation change.

## Winter 1975-76

In contrast to the winter of 1974-75, which was significantly active in the polar region during December and January, the winter of 1975-76 was characterized by a relative lack of large scale circulation perturbations affecting that area. However, there was no lack of circulation anomalies at sub-polar latitudes as may be viewed from the chart series.

A continuous record of thermal oscillations during this winter is given in ref. 24. From their data, it is evident that important thermal and height perturbations occurred, but none of the mid-winter episodes met the criteria for a "major" event.

From the weekly charts presented here, it is evident that temperature perturbations appeared at 0.4 mb over the polar region at the beginning of October. These perturbations continued with periodic movements and changes in amplitude. The changes leading to the temperature configuration on the January 7, 1976 chart can be first noted on December 23, 1975. At that time a warm anomaly was located over the western Atlantic Ocean. By January 14, 1976 the change had led to a large amplitude wave-two circulation pattern at the 5- and 2-mb levels, with an anticyclone centered over Kamchatka and another over the Atlantic.

## Spring 1976

Distortions in the polar cyclone continued to be evident during the following two months. These distortions were mainly associated with mid-latitude anticyclones, which generally traveled from west to east about the periphery of the cyclone. At mid-March there was a pronounced development of an anticyclonic system over the Alaskan area. This system moved to the polar region by the end of the month, resulting in a reversal of the polar circulation from westerly to easterly winds. The change was essentially that of the final springtime reversal, antedating the time of the usual reversal by more than a month. During April, as the polar anticyclone expanded, while increasing in intensity, the cyclonic westerlies moved southward in the form of cellular troughs. By the middle of May the easterlies dominated the hemispheric circulation from the polar area southward to tropical latitudes, where some westerlies still persisted at levels above 5 mb. By the end of June steady easterlies, with only slight meridional components, were evident at all altitudes and over the entire Northern Hemisphere.

Figures 2-13 provide additional views of the changes that took place during the two-year period covered by the chart series. The height and temperature values, plotted as a function of time, were interpolated from the analyzed weekly 5-, 2-, and 0.4-mb charts at six representative locations, ranging from high- to low-latitudes. The annual trend of the height and temperature values is most pronounced at the high- and middle-latitude stations (Figs. 2-9), with the largest range of values occurring at the more northerly stations. Superposed on this annual trend, characterized by maximum values in summer and minimum values in winter, are various perturbations. The largest of these perturbations occurred at the end of December 1974 and was associated with the large-scale stratospheric warming of the upper stratosphere. Other, smaller perturbations affecting the fields at the various stations are seen from the time sections. These were associated with smaller scale disturbances throughout the 1974-75 and 1975-76 winter and spring transition periods and movements of the Aleutian Anticyclone. At the tropical station of Antigua, West Indies Associated State (W.I.A.S.) the range of values is very small, with only minor perturbations affecting the station (Figs. 12 and 13). There is a suggestion, however, of a double maximum at the time of the equinoxes associated with the semiannual variation in temperature and wind, and related to the seasonal migration of the subtropical anticyclone as seen in the charts. At the subtropical station of White Sands, New Mexico (Figs. 10 and 11), a combination of the annual variation and the semiannual variation is apparent.

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## REFERENCES

1. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Mb. Surfaces for 1964," ESSA Technical Report WB 2, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, April 1967, 197 pp.
2. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Mb. Surfaces for 1965," ESSA Technical Report WB 3, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, August 1967, 173 pp.
3. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for 1966," ESSA Technical Report WB 9, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, January 1969, 169 pp.
4. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for 1967," ESSA Technical Report WB 12, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, January 1970, 169 pp.
5. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for 1968," NOAA Technical Report NWS 14, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland, May 1971, 169 pp.
6. Finger, Frederick G., Woolf, Harold M., and Anderson, Calvin E., "Synoptic Analyses of the 5-, 2-, and 0.4-Millibar Surfaces for the IQSY Period," Monthly Weather Review, Vol. 94, No. 11, November 1966, pp. 651-661.
7. World Data Center A, Meteorology, Data Report, Meteorological Rocket Network Firings 1964-1968, Vol. I-V, National Weather Records Center, Environmental Science Services Administration, U.S. Department of Commerce, Asheville, North Carolina, 1967-1971.
8. Staff, Upper Air Branch, National Meteorological Center, "Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for January 1972 Through June 1973," Joint NASA-NOAA Publication, NASA SP-3091, National Aeronautics and Space Administration, Washington, D.C., 1975, 205 pp.

9. Staff, Upper Air Branch, National Meteorological Center, "Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for July 1973 Through June 1974," Joint NASA-NOAA Publication, NASA SP-3102, National Aeronautics and Space Administration, Washington, D.C., 1976, 140 pp.
10. EXAMETNET, Experimental InterAmerican Meteorological Rocket Network: 8th Annual Meeting Report, October 30-November 3, 1972, Mar del Plata, Argentina, Comision Nacional De Investigaciones Espaciales, Argentina, 180 pp.
11. Muench, H. Stuart, "Large-Scale Disturbances in the Summer-time Stratosphere," Journal of the Atmospheric Sciences, Vol. 25, No. 6, November 1968, pp. 1108-1115.
12. Hirota, Isamu, "Spectral Analysis of Planetary Waves in the Summer Stratosphere and Mesosphere," Journal of the Meteor. Soc. of Japan, Vol. 53, No. 1, February 1975, pp. 33-44.
13. Krumins, M. V., and Lyons, W. C., "Corrections for the Upper Atmosphere Temperatures Using a Thin Film Loop Mount," Technical Report 72-152, Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland, June 1972, 38 pp.
14. U.S. National Aeronautics and Space Administration, U.S. Department of Commerce, and U.S. Department of Defense, "Meteorological Rocket Observations," Federal Handbook No. 10, July 1975, approximately 250 pp.
15. Finger, Frederick G., Gelman, Melvyn E., Schmidlin, Francis J., Leviton, Robert, and Kennedy, Bruce W., "Compatibility of Meteorological Rocketsonde Data as Indicated by International Comparison Tests," Journal of Atmospheric Sciences, Vol. 32, No. 9, September 1975, pp. 1705-1714.
16. McMillin, L. M., Wark, D. Q., Siomkajlo, J. M., Abel, P. G., Werbowetzki, A., Lauritson, L. A., Pritchard, J. A., Crosby, D. S., Woolf, H. M., Luebke, R. C., Weinreb, M. P., Fleming, H. E., Bittner, F. E., and Hayden, C. M., "Satellite Infrared Soundings From NOAA Spacecraft," NOAA Technical Report NESS 65, National Environmental Satellite Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C., September 1973, 112 pp.
17. Goddard Space Flight Center, "The Nimbus 5 User's Guide," Nimbus Project, U.S. National Aeronautics and Space Administration, Greenbelt, Maryland, November 1972, 162 pp.

18. Quiroz, Roderick S., and Gelman, Melvyn E., "Direct Determination of the Thickness of Stratospheric Layers From Single-Channel Satellite Radiance Measurements," Monthly Weather Review, Vol. 100, No. 11, November 1972, pp. 788-795.
19. NOAA, National Oceanic and Atmospheric Administration, "Constant Pressure Charts 850-10 Mb," National Climatic Center MF-494-74, 76, U.S. Department of Commerce, Asheville, North Carolina, 1974-1976.
20. Quiroz, Roderick S., "The Stratospheric Evolution of Sudden Warmings in 1969-74 Determined From Measured Infrared Radiation Fields," Journal of the Atmospheric Sciences, Vol. 32, No. 1, January 1975, pp. 211-224.
21. Miller, Alvin J., "A Note on the Variability of Temperature as Indicated by Rocketsonde Thermistors," Journal of Applied Meteorology, Vol. 8, No. 1, February 1969, pp. 172-174.
22. Miller, Alvin J., and Schmidlin, Francis J., "Rocketsonde Repeatability and Stratospheric Variability," Journal of Applied Meteorology, Vol. 10, No. 2, April 1971, pp. 320-327.
23. Quiroz, Roderick S., Miller, Alvin J., and Nagatani, Ronald M., "A Comparison of Observed and Simulated Properties of Sudden Stratospheric Warmings," Journal of the Atmospheric Sciences, Vol. 32, No. 9, September 1975, pp. 1723-1736.
24. Quiroz, Roderick S., and Nagatani, Ronald M., "A Study of Tropospheric-Stratospheric Interaction Based on Combined Satellite and Rawinsonde Data," Symp. on Meteor. Obs. from Space (COSPAR Meeting, Philadelphia, June 8-10, 1976), Proceedings, pp. 368-373, NCAR Publication, Boulder, Colorado, September 1976.



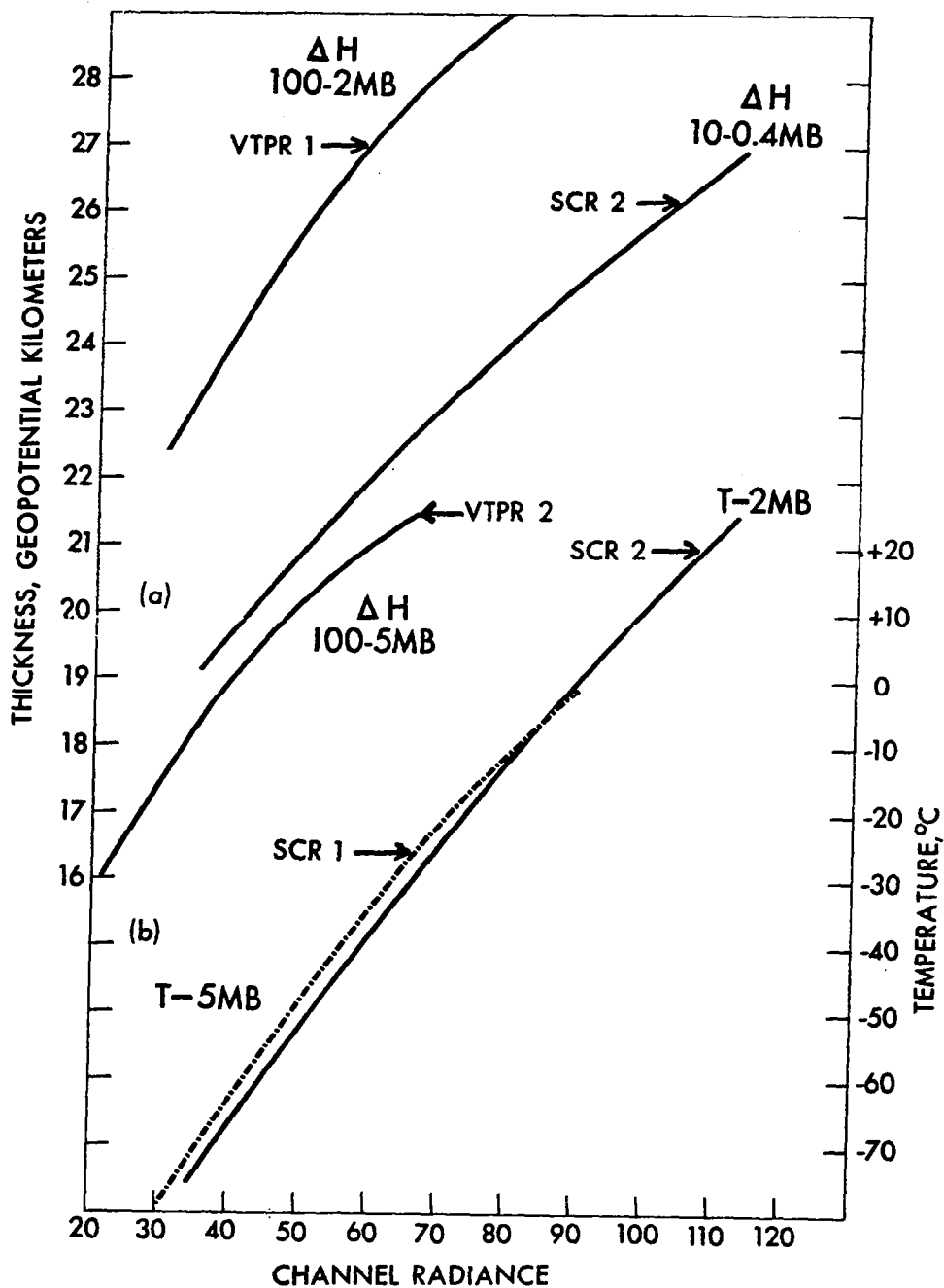


Figure 1. Relationships between satellite-measured radiances and thickness (a); and between radiance and temperature (b). The following relationships are shown: VTPR (NOAA 3 and 4) channel 1 for thickness between 100 to 2 mb; VTPR channel 2 for thickness between 100 to 5 mb; SCR (Nimbus 5) channel 2 for thickness between 10 to 0.4 mb; SCR channel 1 for temperature for 5 mb; and SCR channel 2 for temperature at 2 mb. Radiance units  $10^{-7} \text{ J. cm}^{-2} \cdot \text{s}^{-1} \cdot (\text{ster})^{-1} \cdot (\text{cm}^{-1})^{-1}$ .

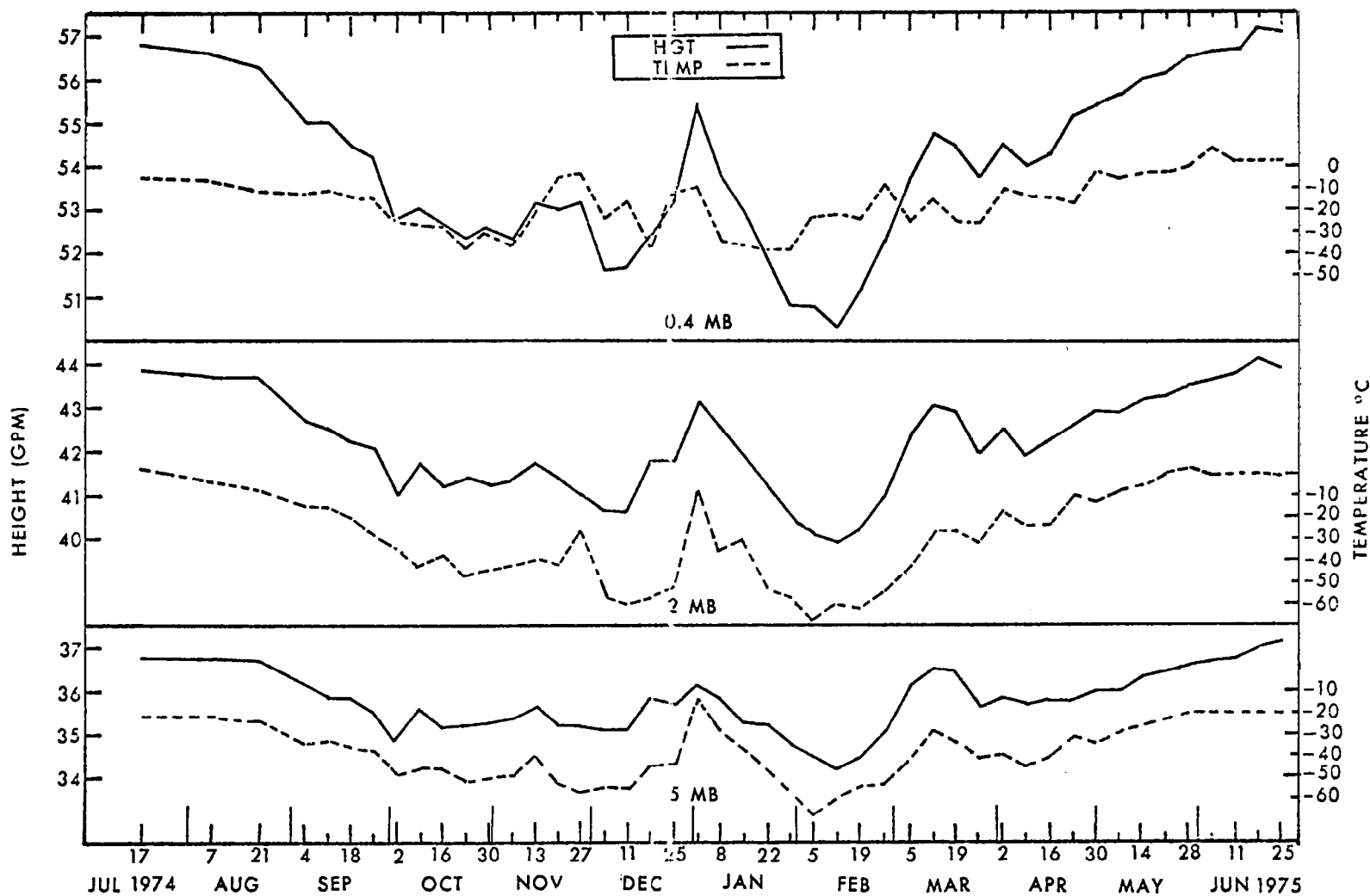


Figure 2. Poker Flat, Alaska (65°07'N, 147°29'W) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1974 to June 1975.

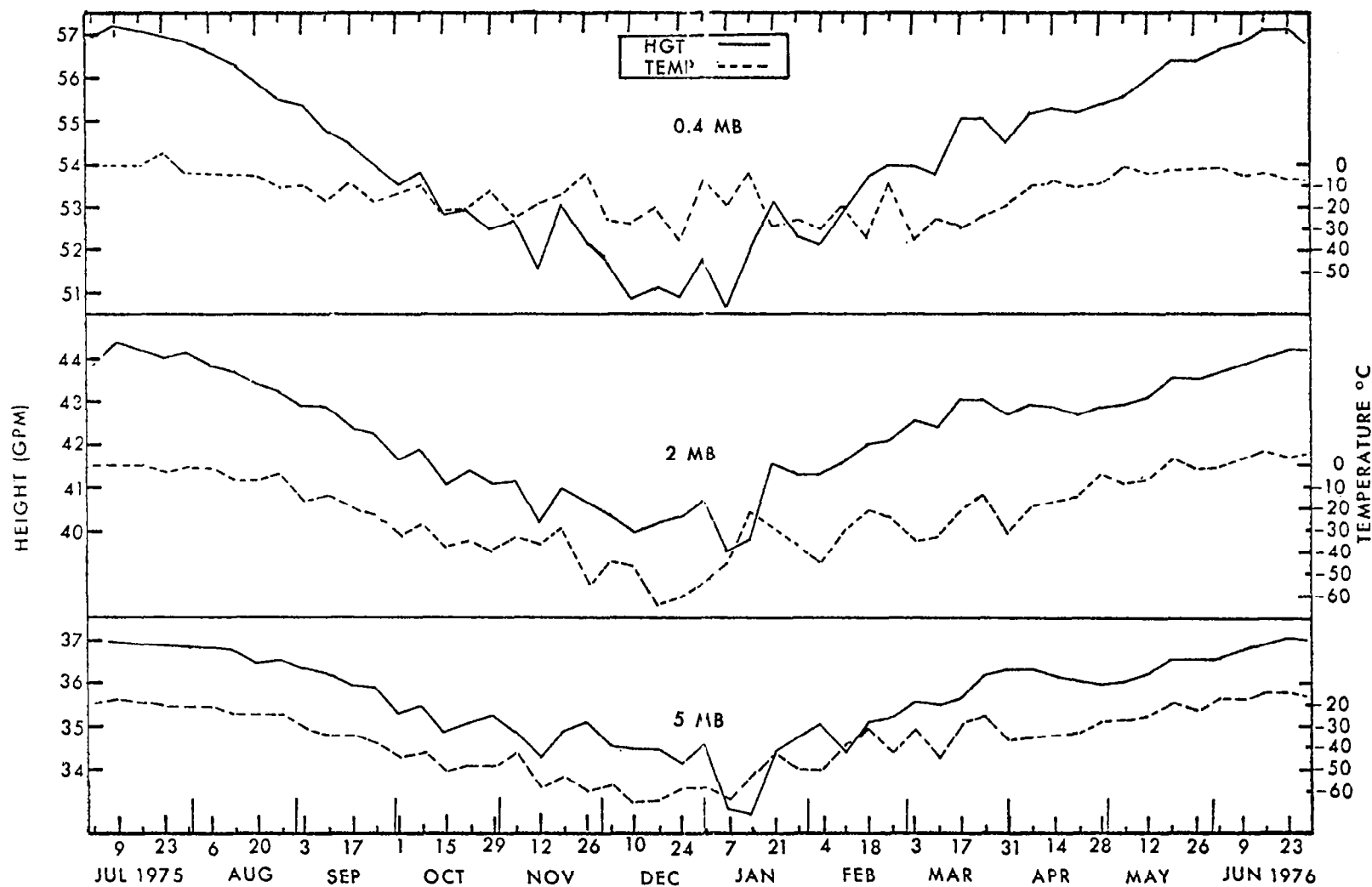


Figure 3. Poker Flat, Alaska ( $65^{\circ}07'N$ ,  $147^{\circ}29'W$ ) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1975 to June 1976.

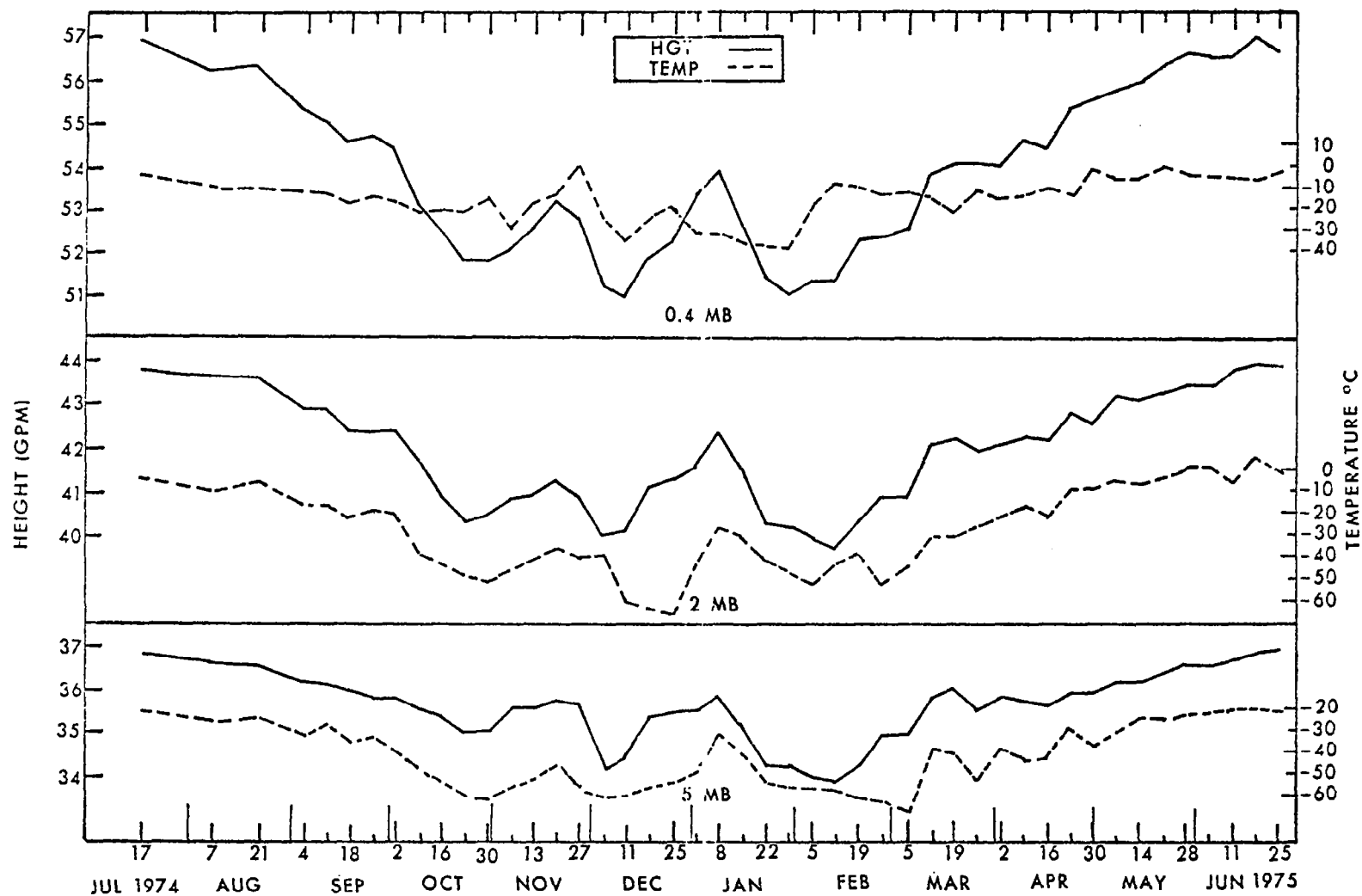


Figure 4. Fort Churchill, Canada (58°44'N, 93°49'W) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1974 to June 1975.

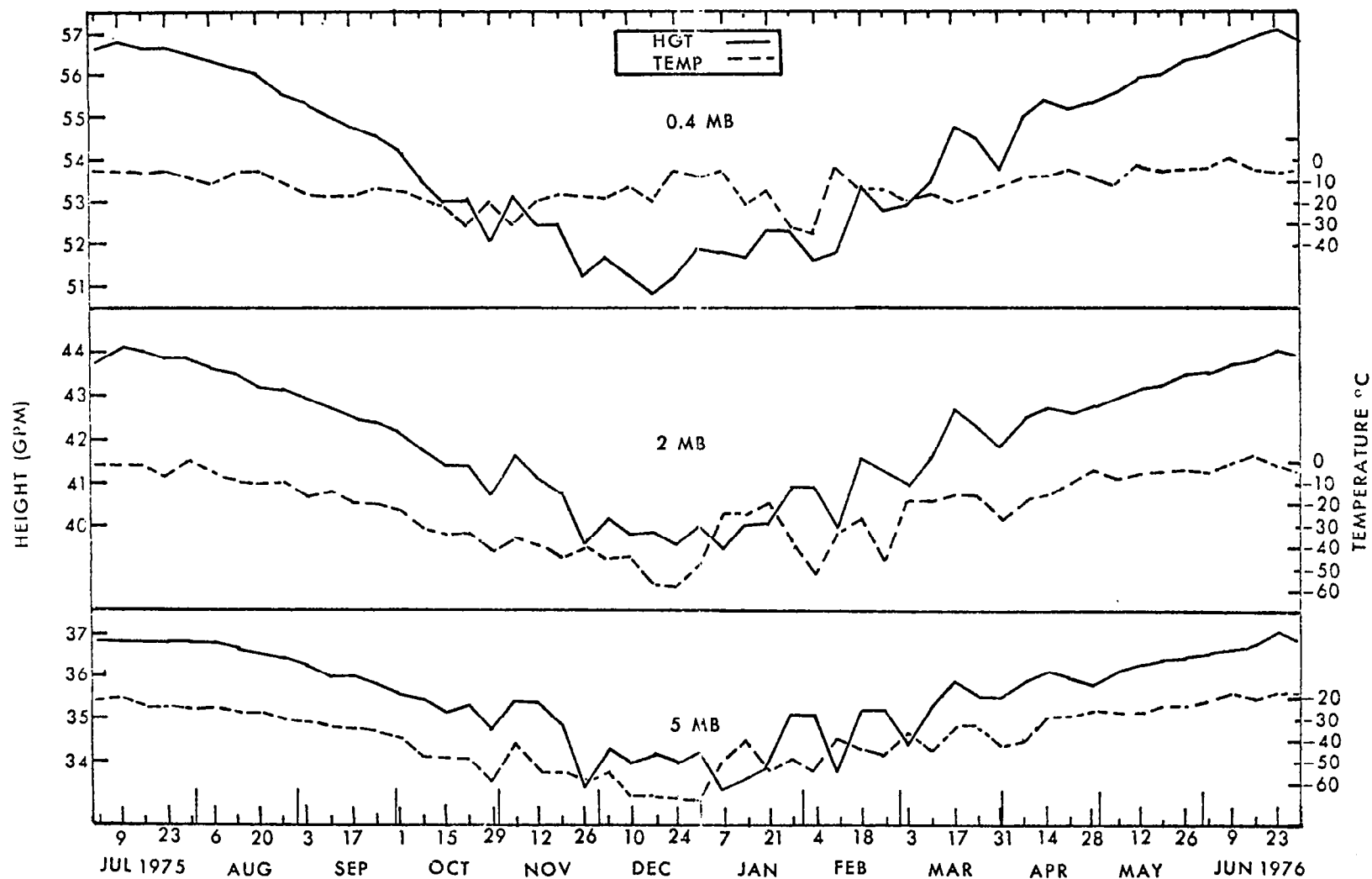


Figure 5. Fort Churchill, Canada ( $58^{\circ}44'N$ ,  $93^{\circ}49'W$ ) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1975 to June 1976.

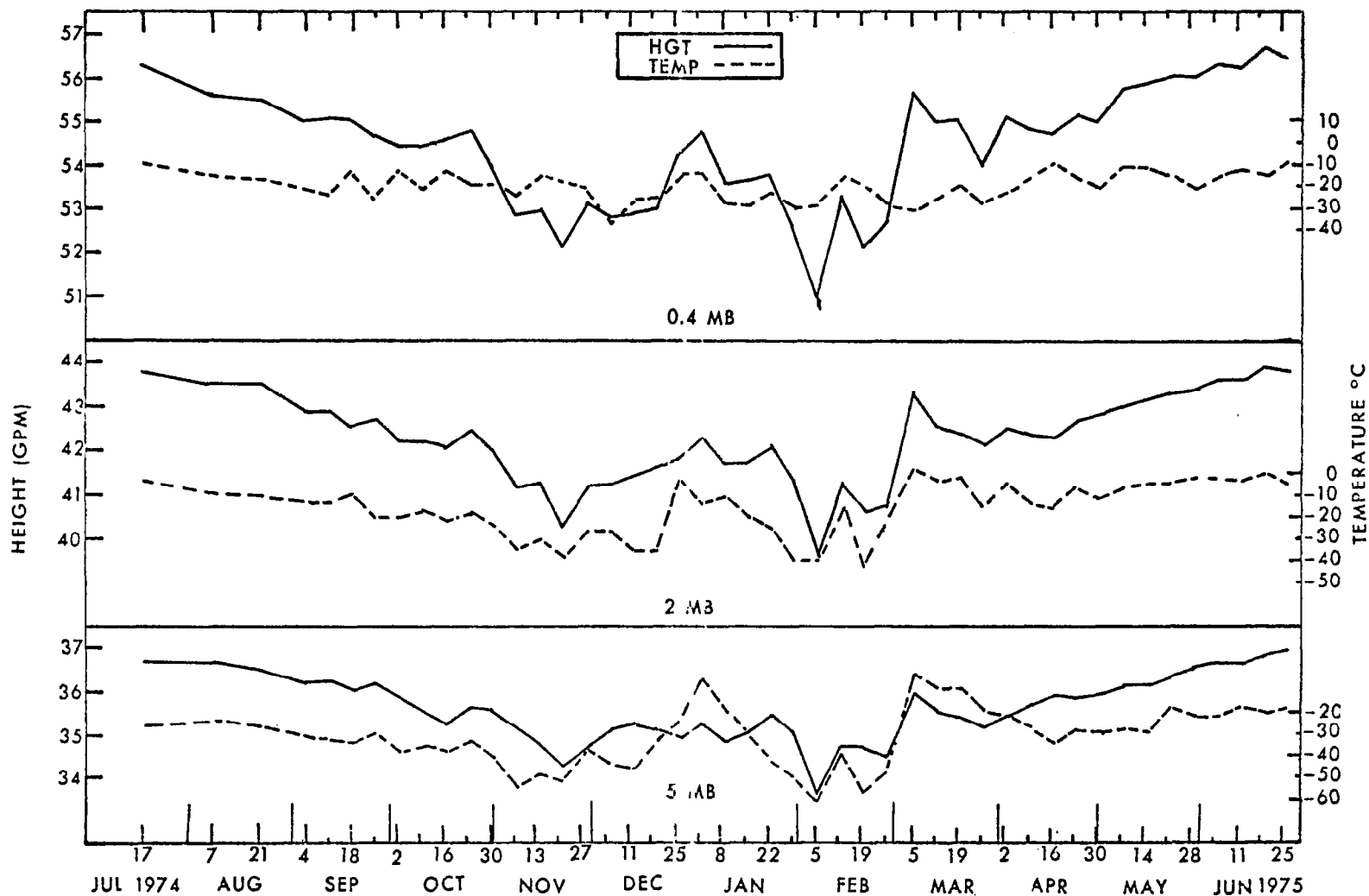


Figure 6. Volgograd, U.S.S.R. ( $48^{\circ}41'N$ ,  $44^{\circ}21'E$ ) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1974 to June 1975.

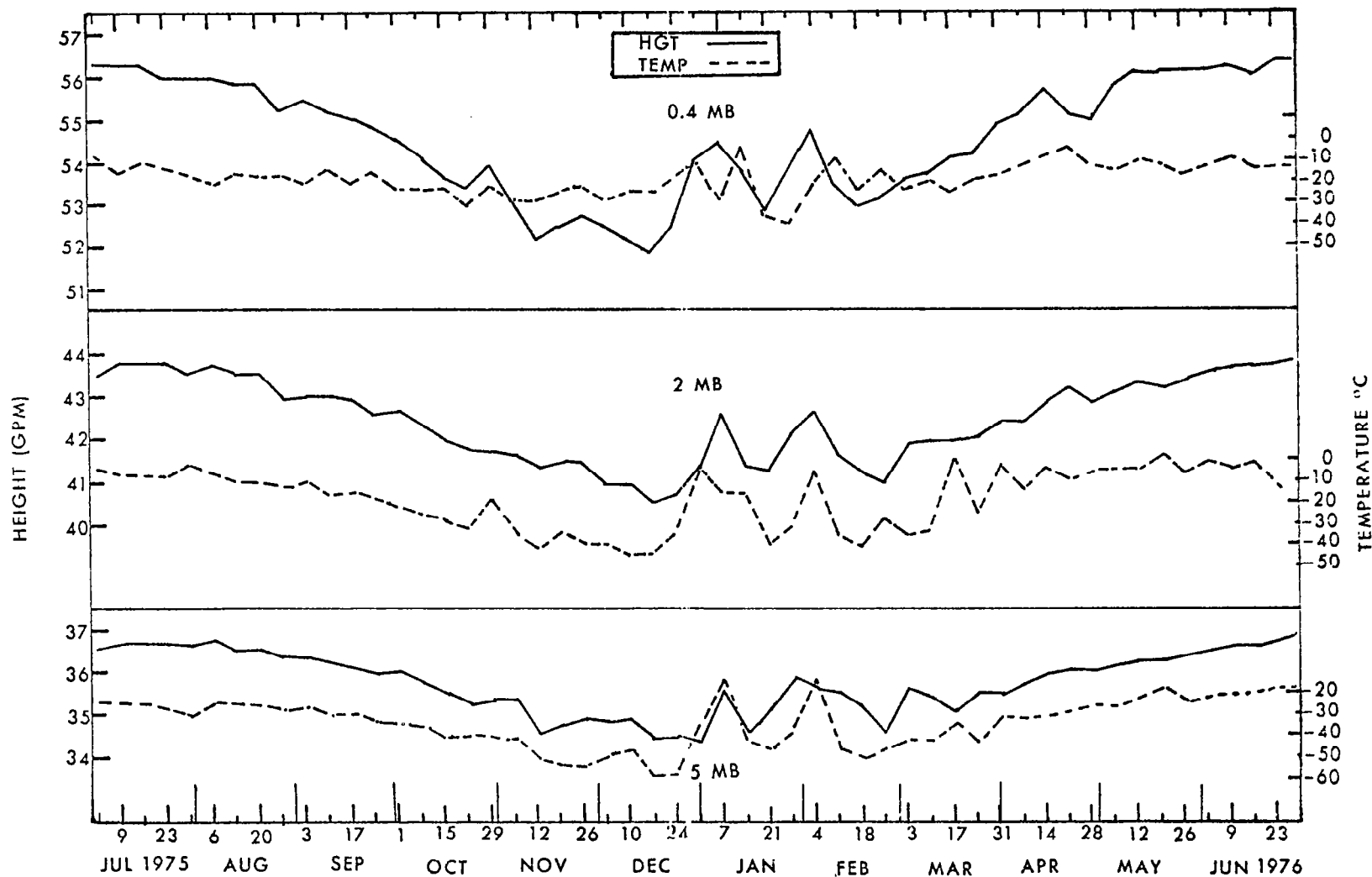


Figure 7. Volgograd, U.S.S.R. (48°41'N, 44°21'E) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1975 to June 1976.

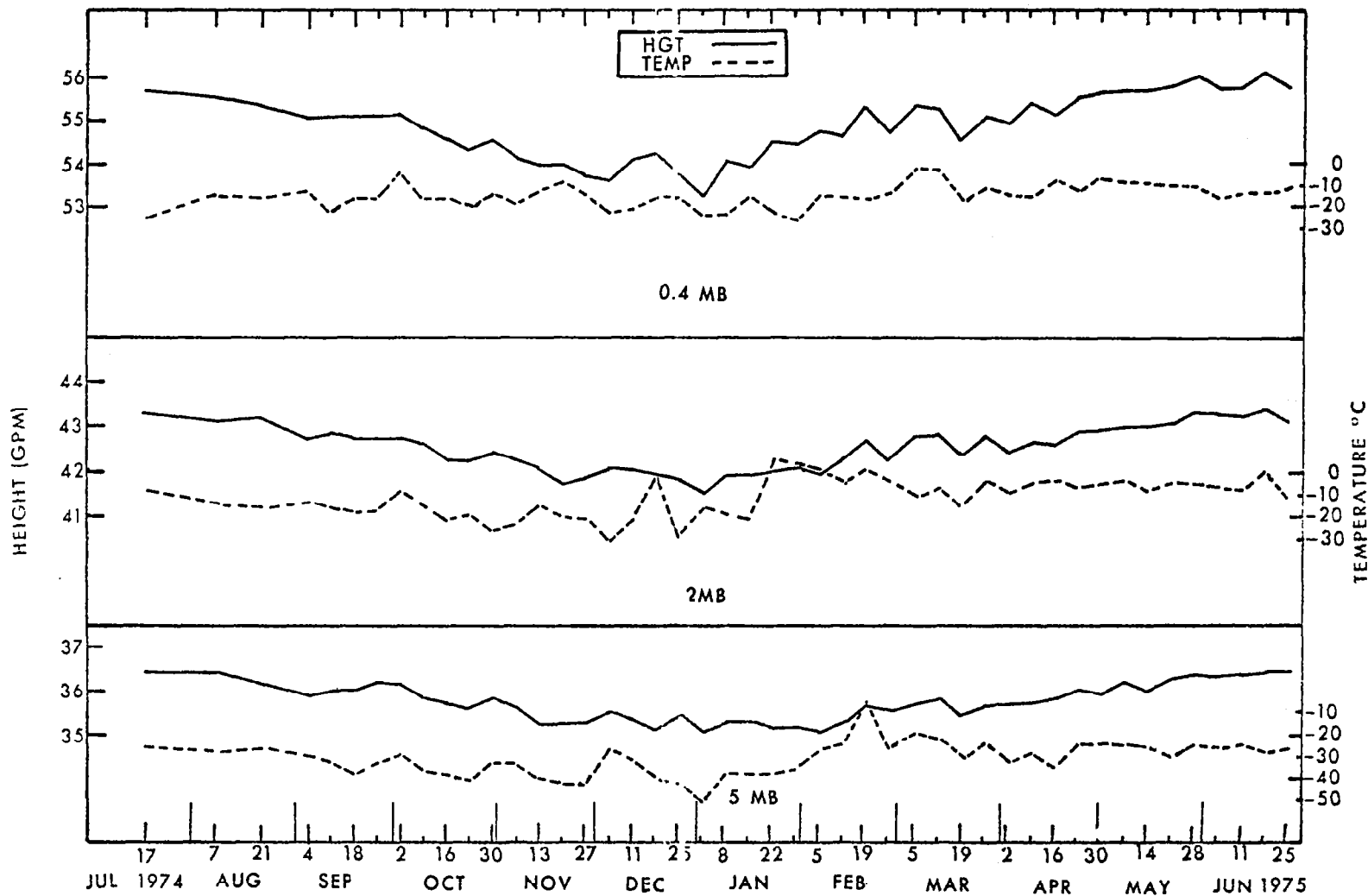


Figure 8. Wallops Island, Virginia (37°50'N, 75°29'W) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1974 to June 1975.



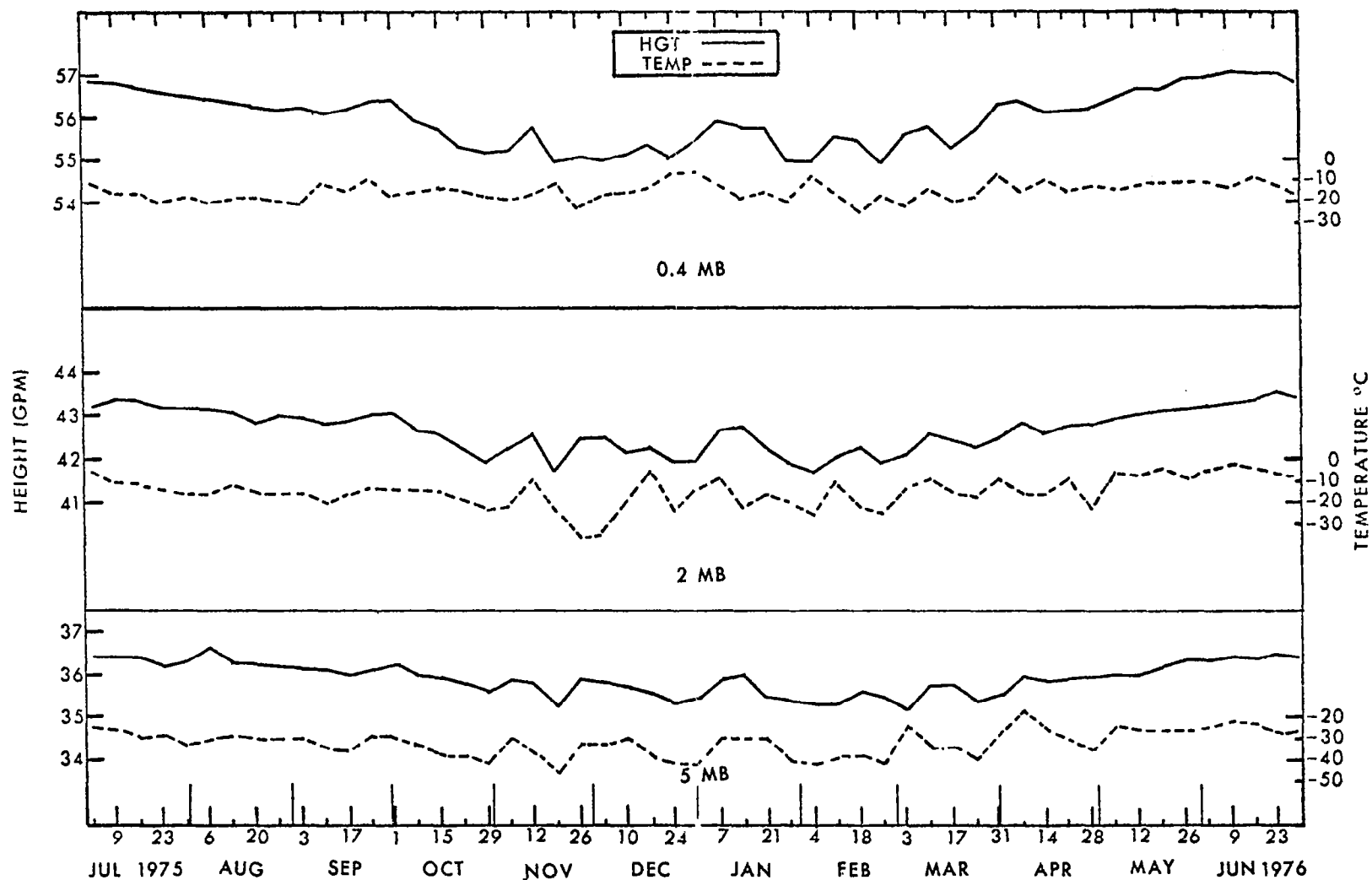


Figure 9. Wallops Island, Virginia ( $37^{\circ}50'N$ ,  $75^{\circ}29'W$ ) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1975 to June 1976.

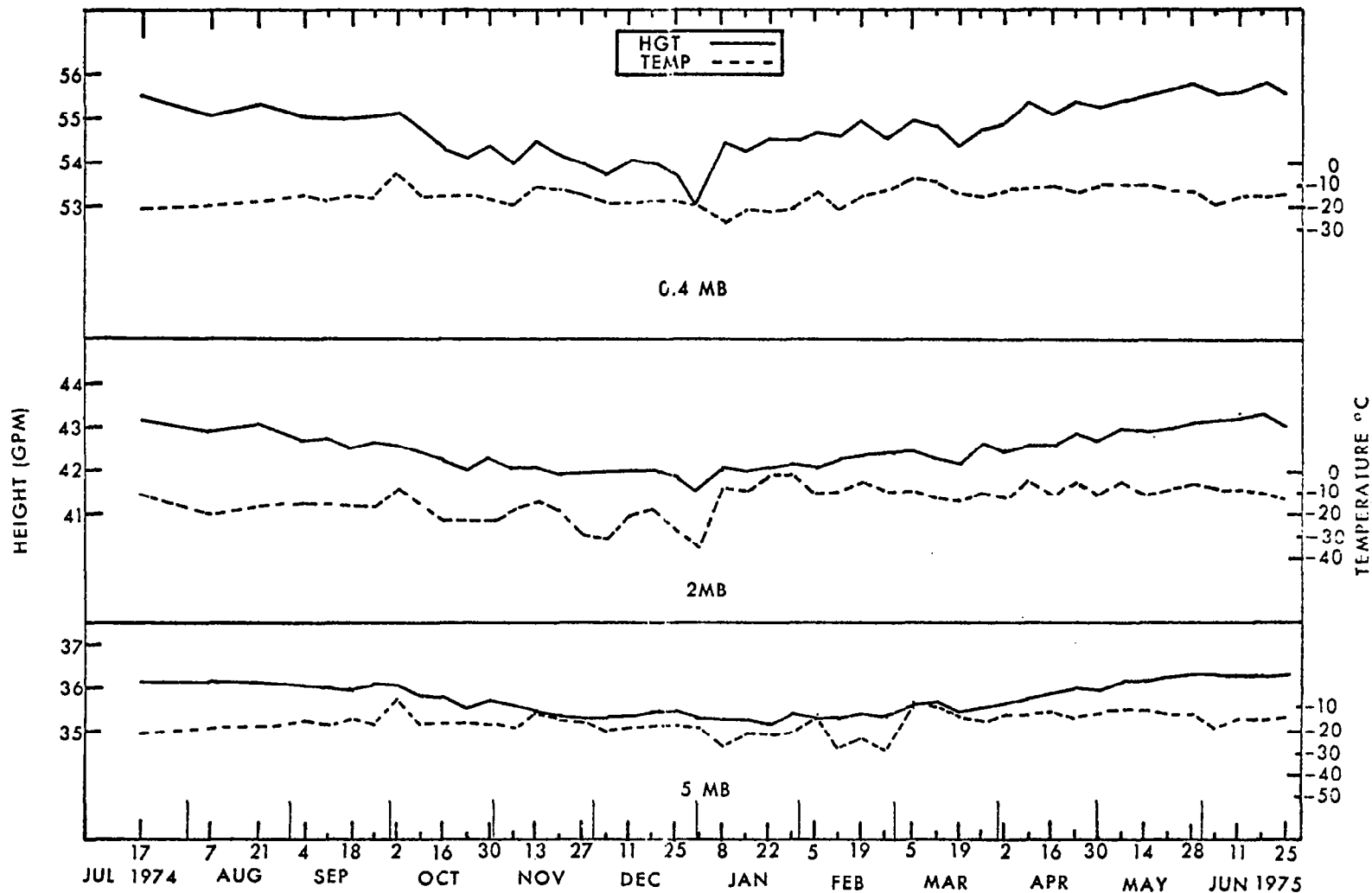


Figure 10. White Sands, New Mexico ( $32^{\circ}23'N$ ,  $106^{\circ}29'W$ ) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1974 to June 1975.

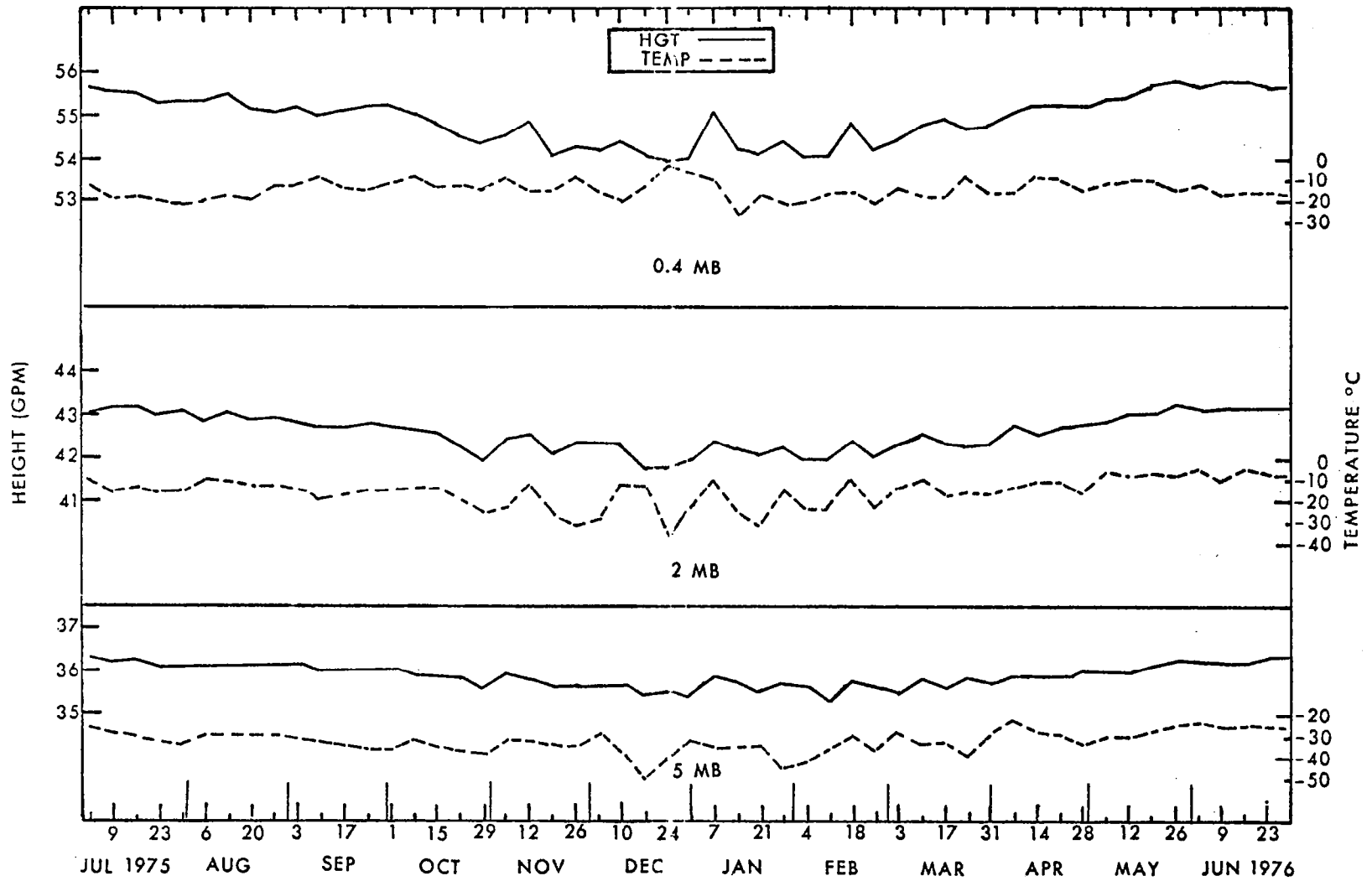


Figure 11. White Sands, New Mexico (32°23'N, 106°29'W) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1975 to June 1976.

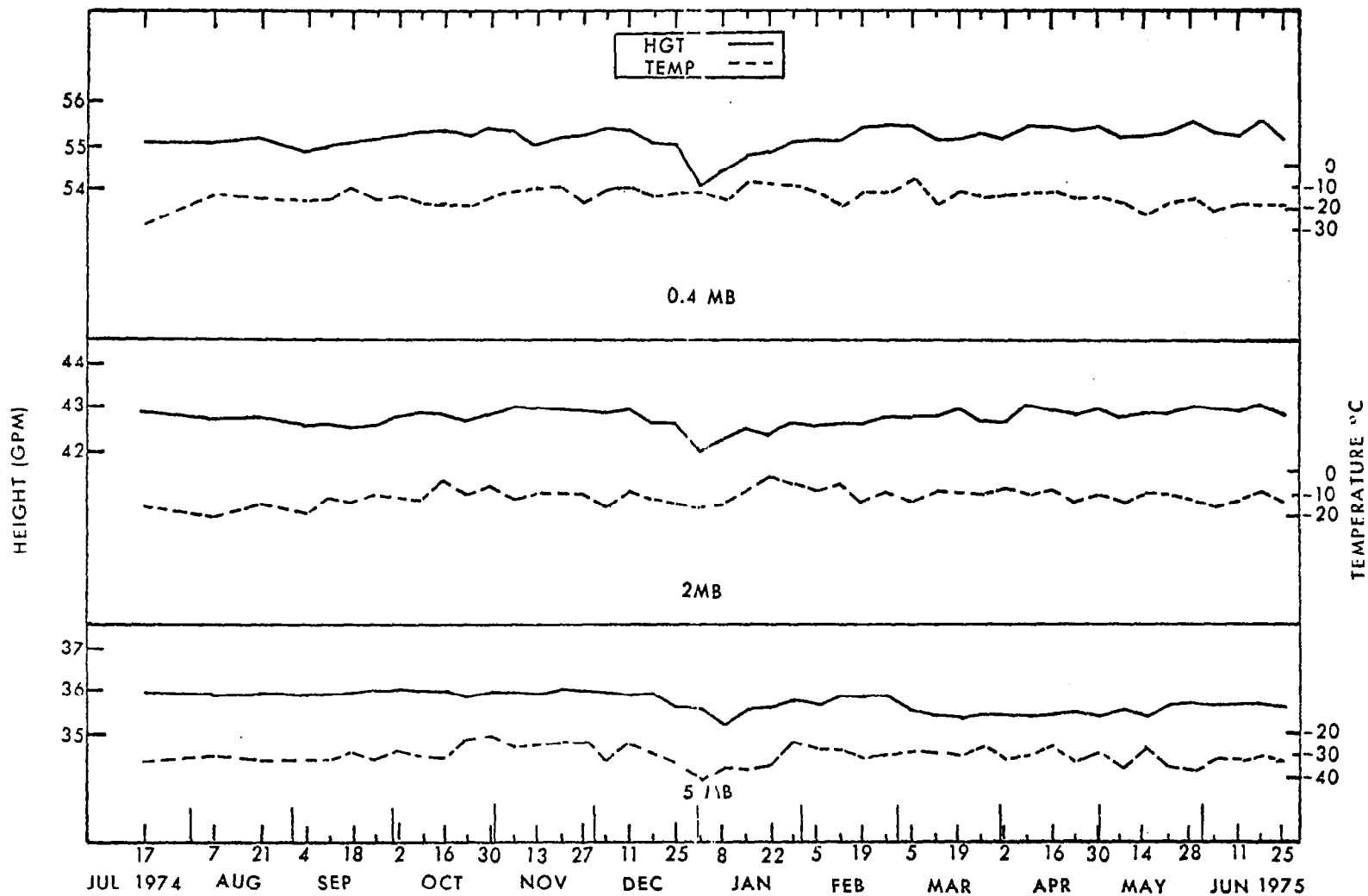


Figure 12. Antigua, W.I.A.S. ( $17^{\circ}08'N$ ,  $61^{\circ}47'W$ ) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1974 to June 1975.

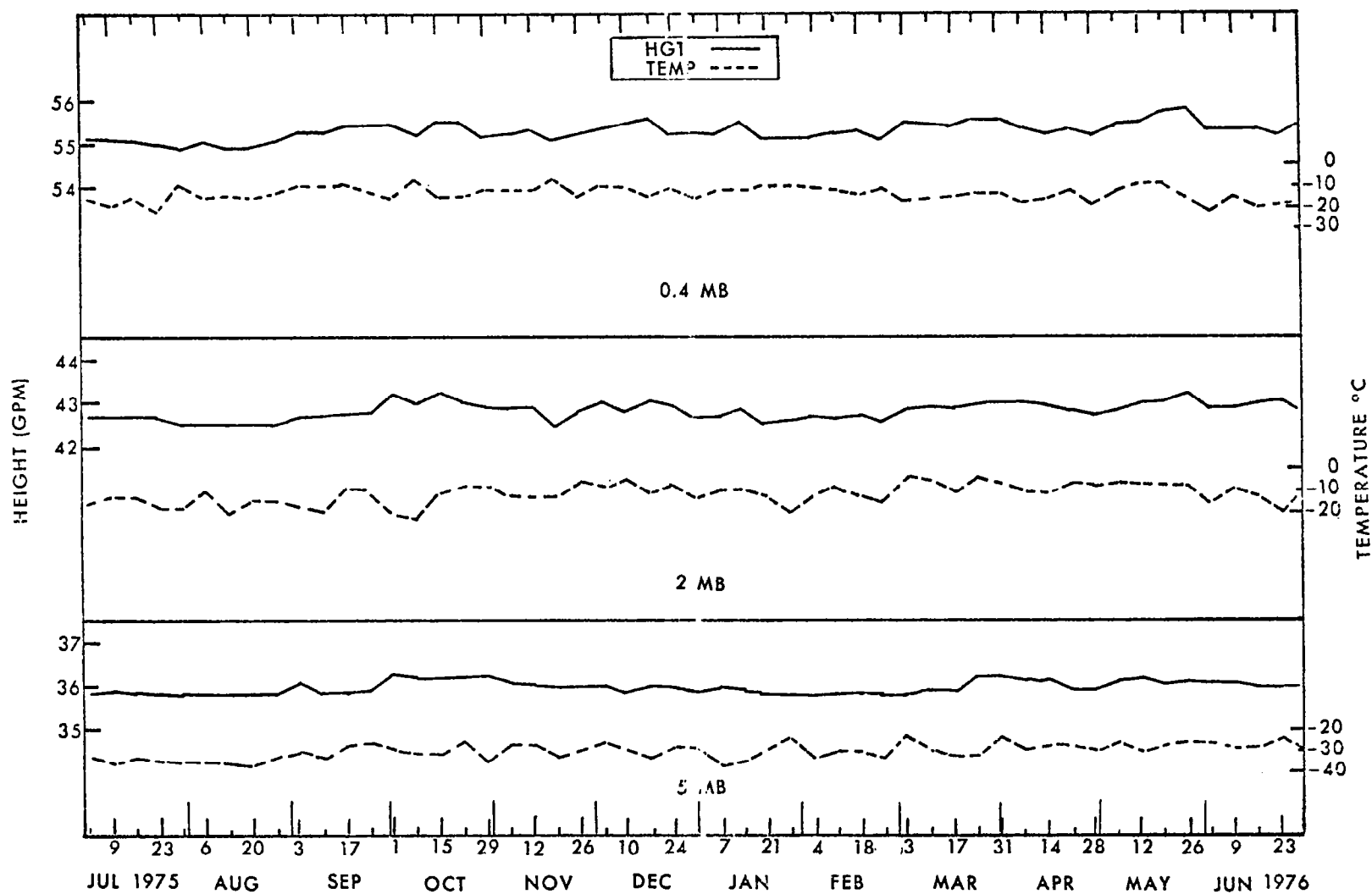


Figure 13. Antigua, W.I.A.S. ( $17^{\circ}08'N$ ,  $61^{\circ}47'W$ ) analyzed values extracted from the 5-, 2-, and 0.4-mb charts for July 1975 to June 1976.

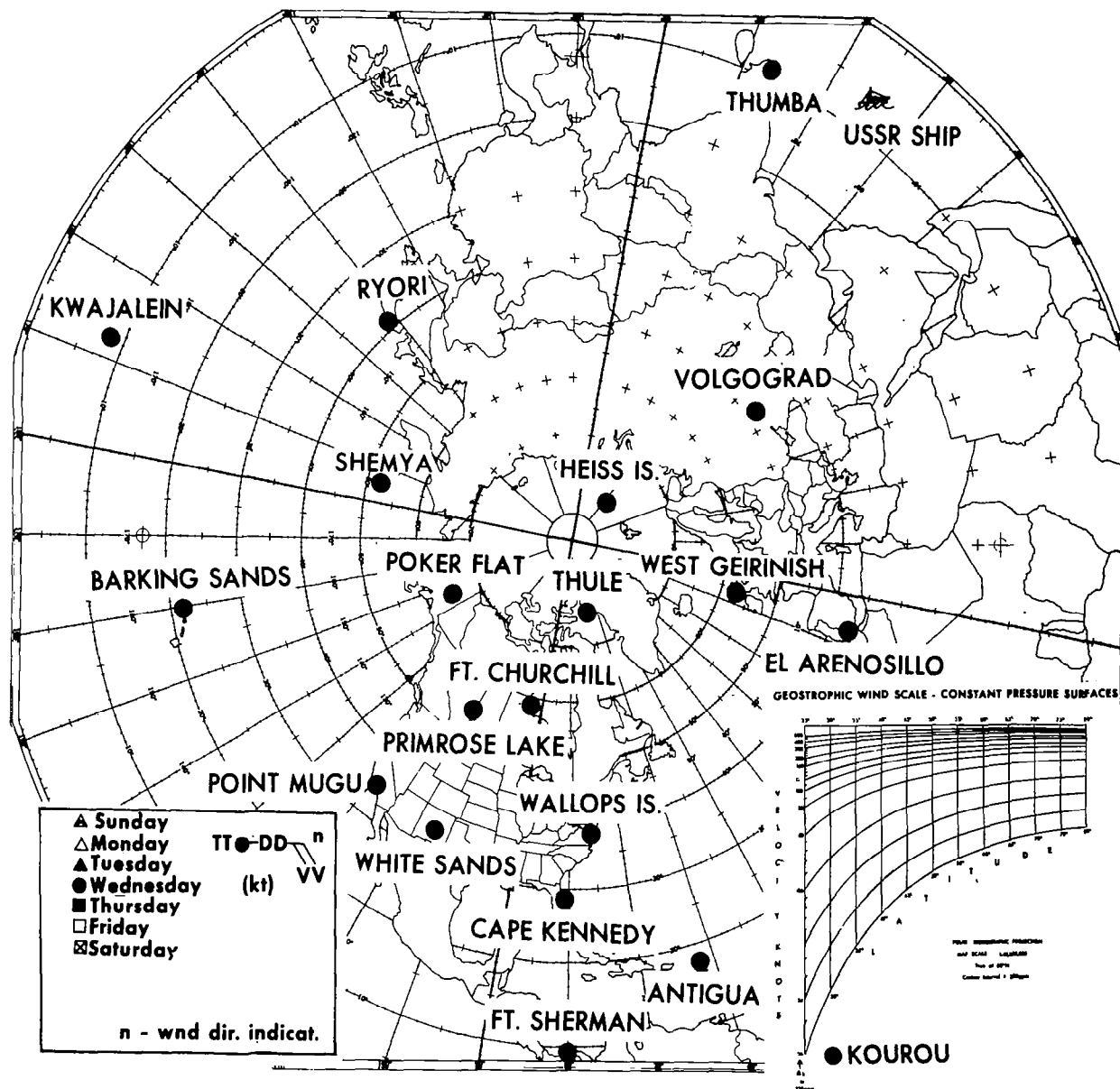
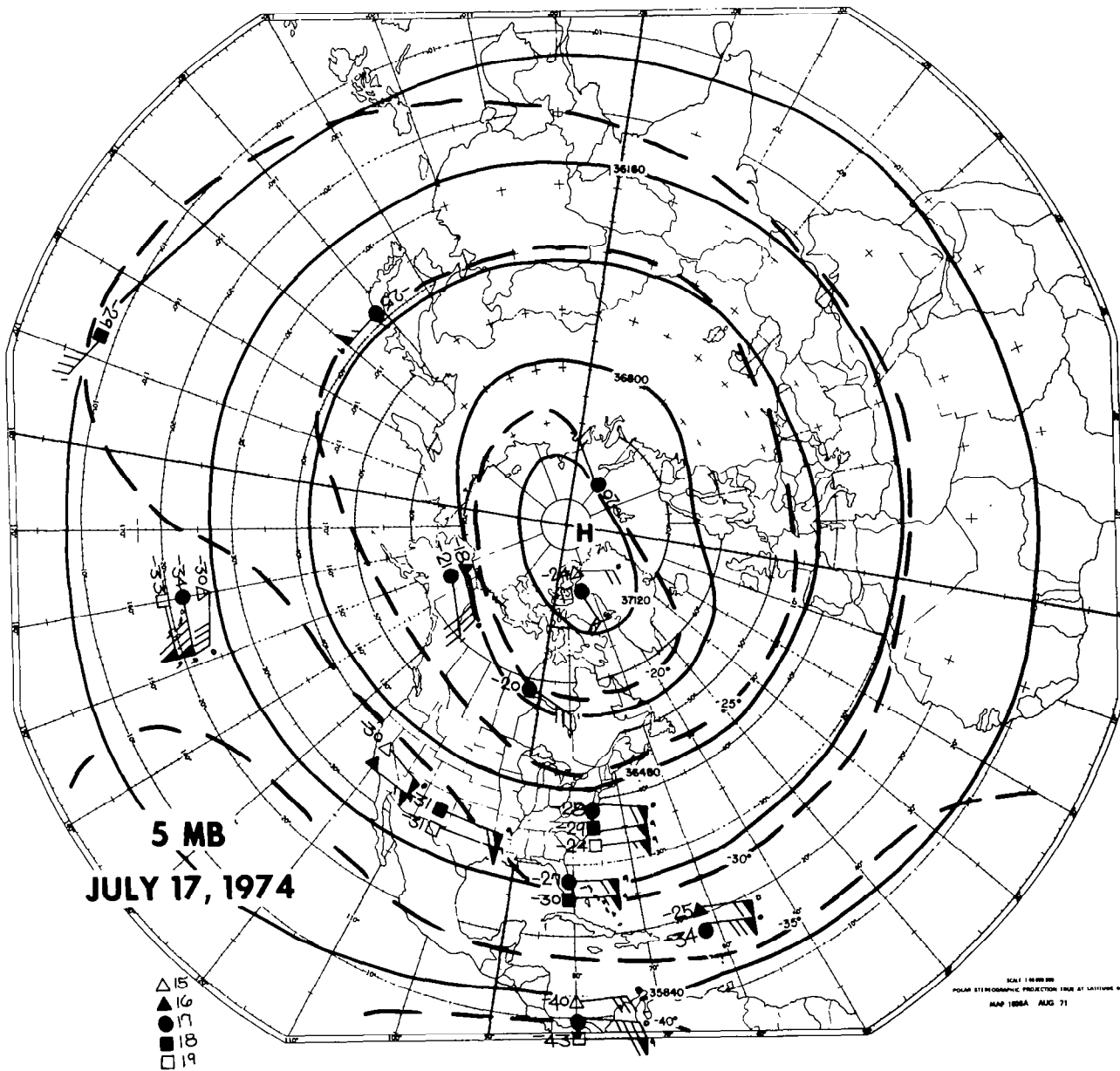
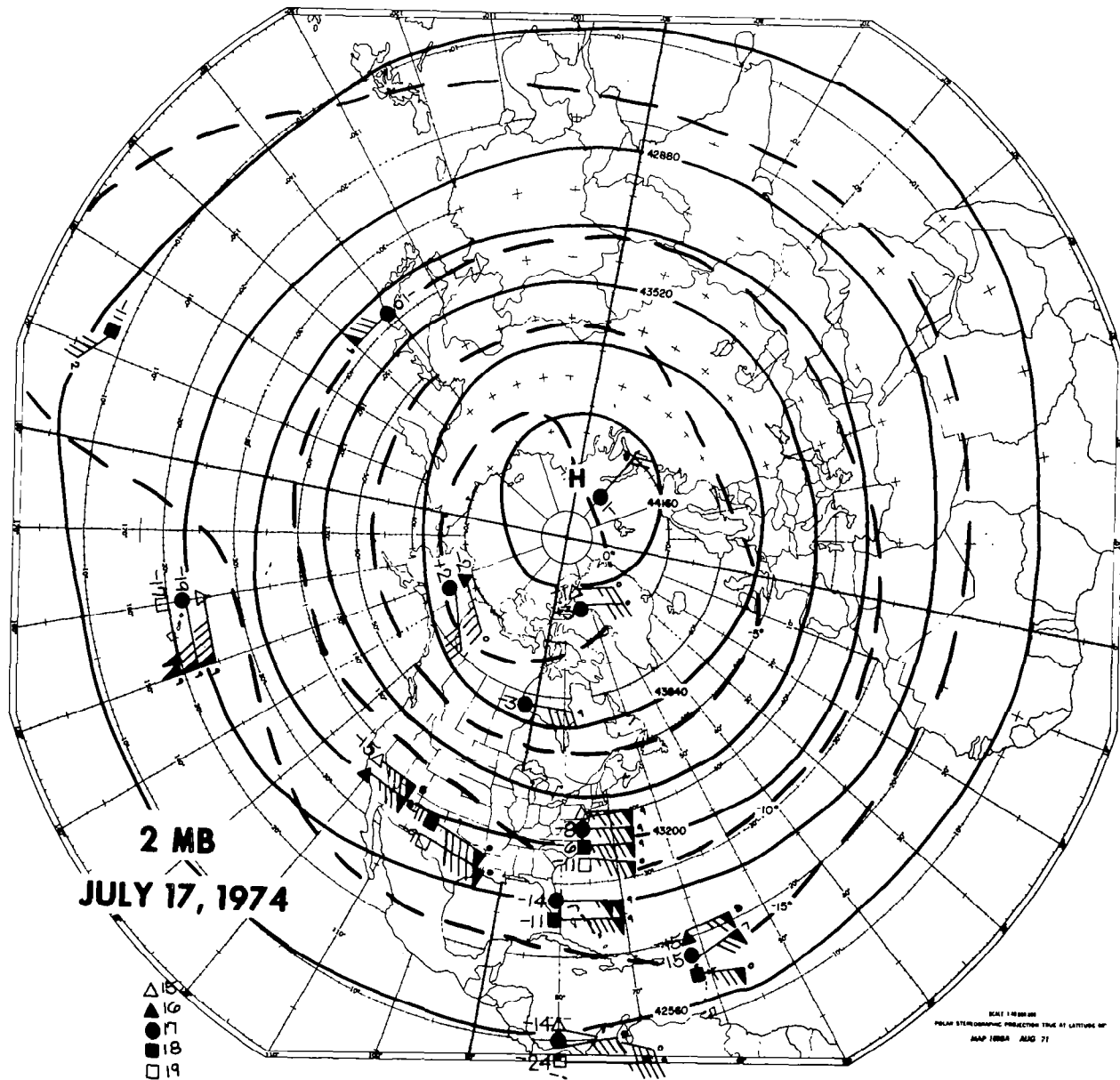
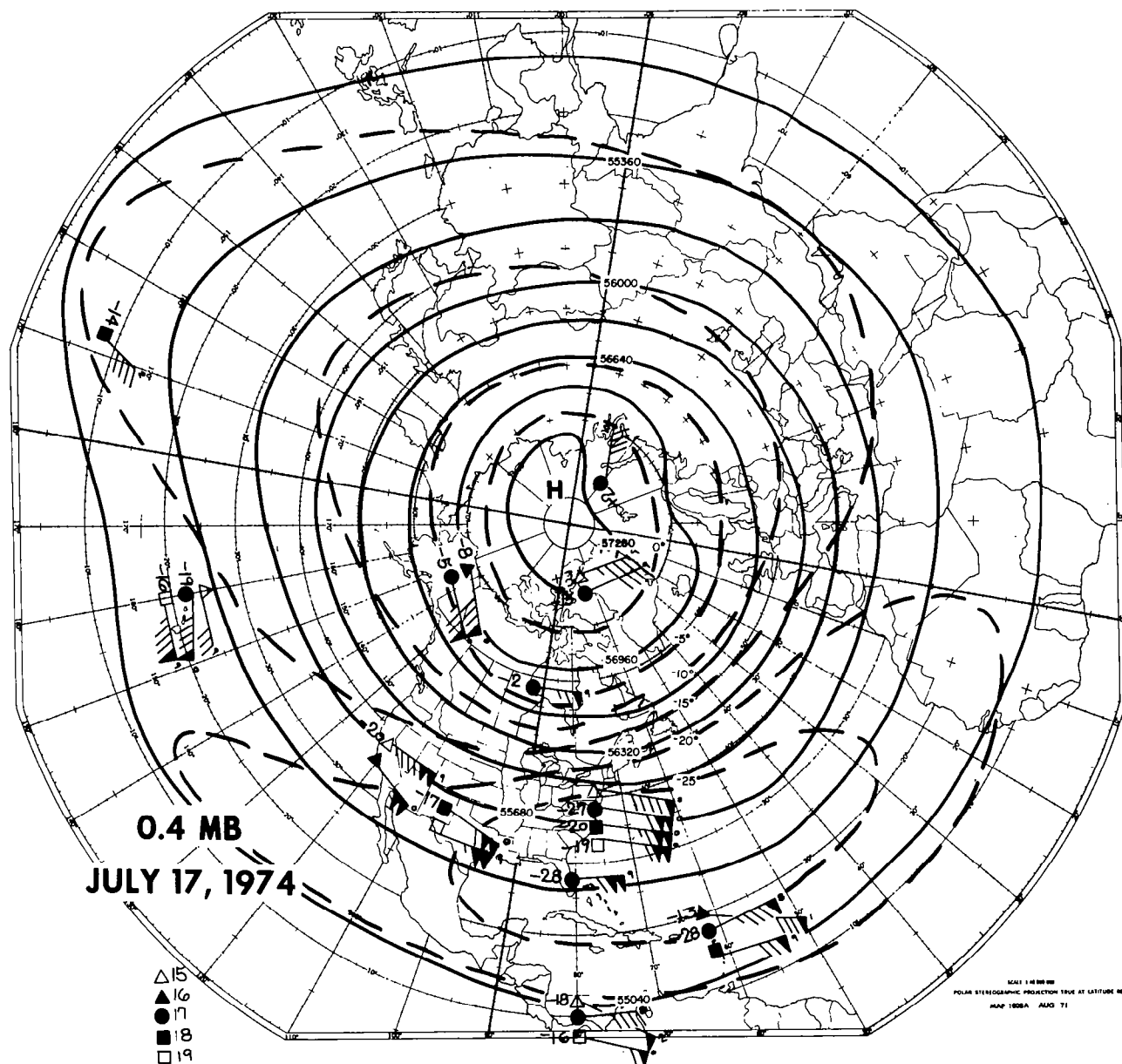


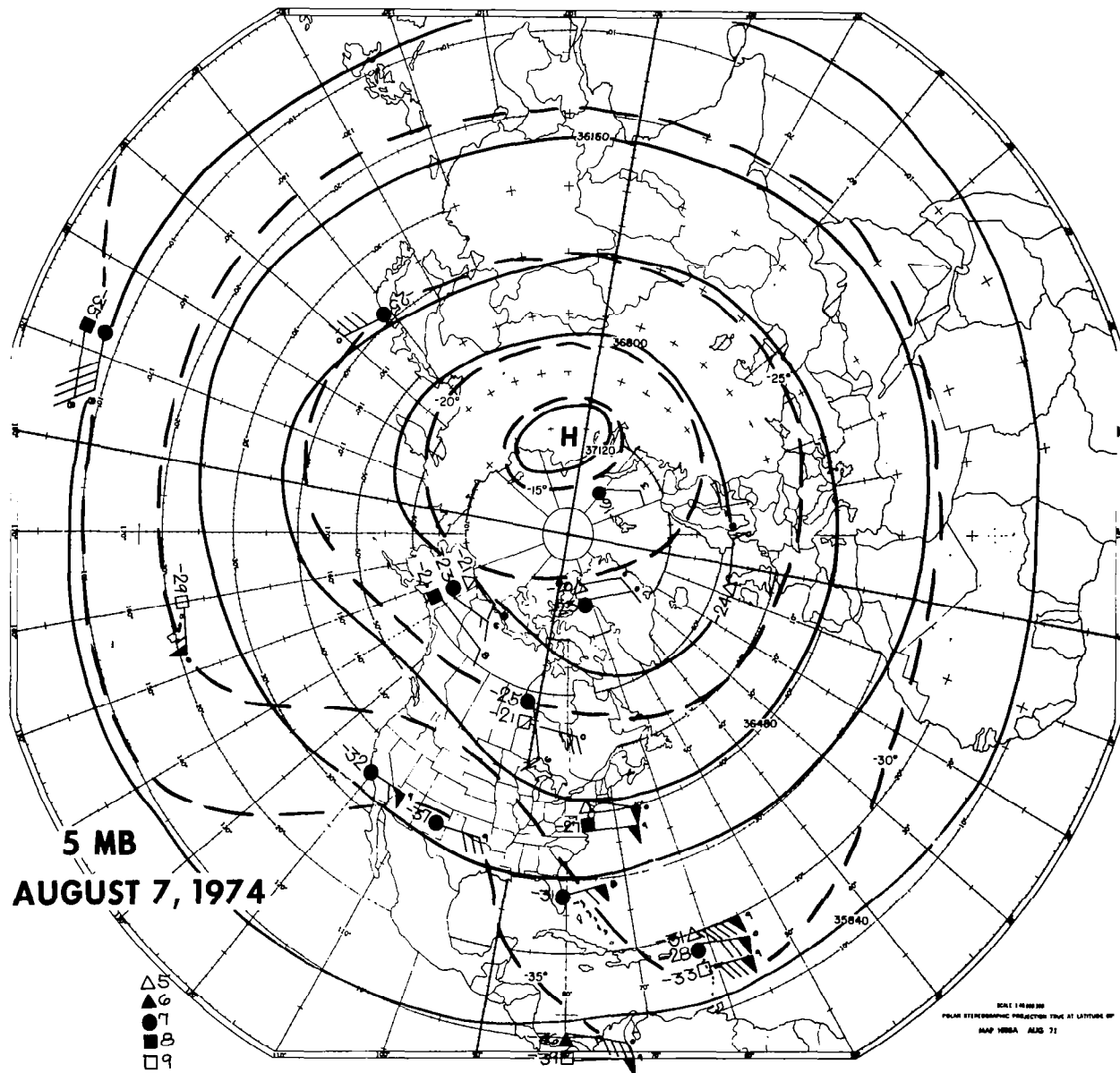
Figure 14. Northern Hemisphere map with locations of 19 rocketsonde stations and one mobile ship. Model for plotted rocketsonde data and a geostrophic wind scale are also shown.

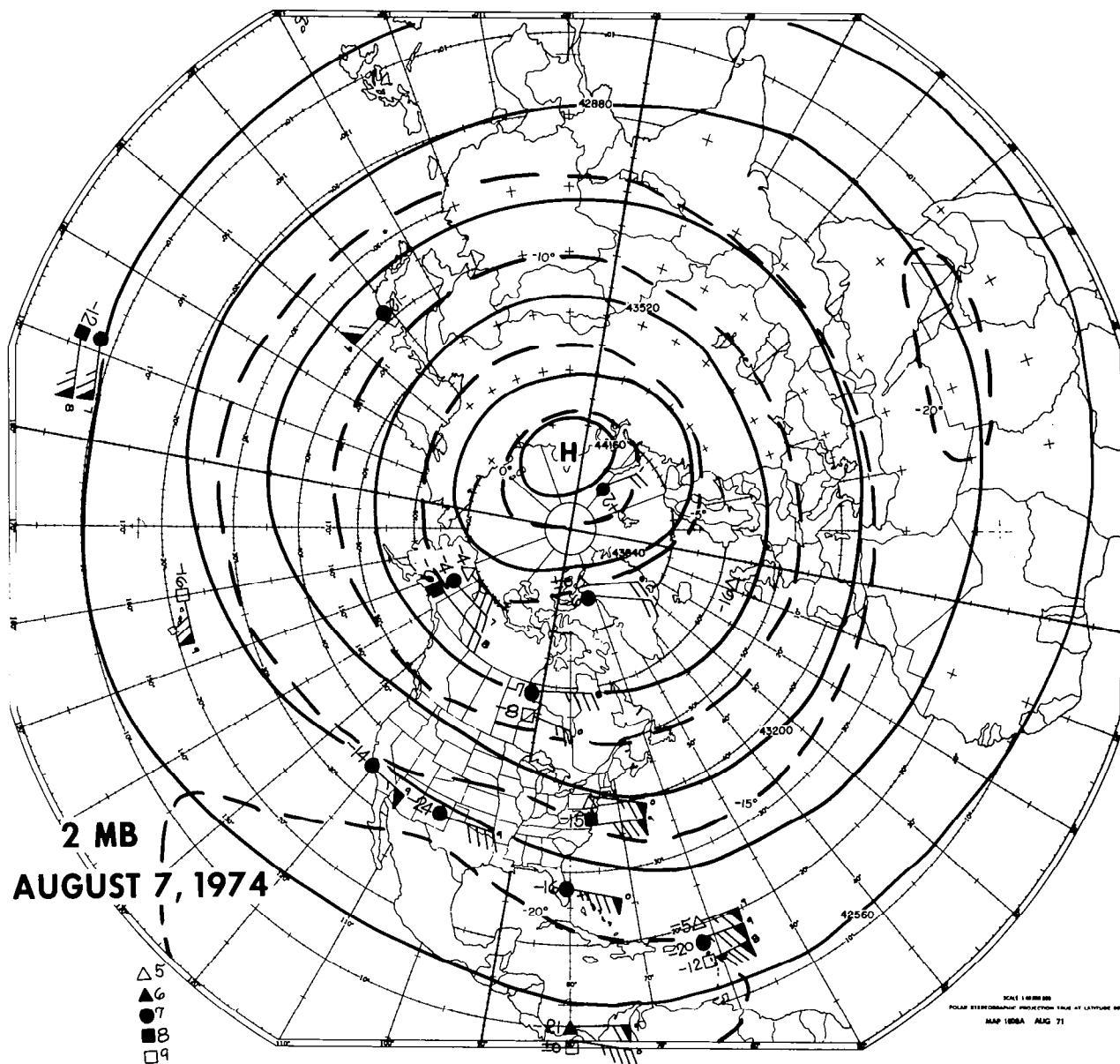


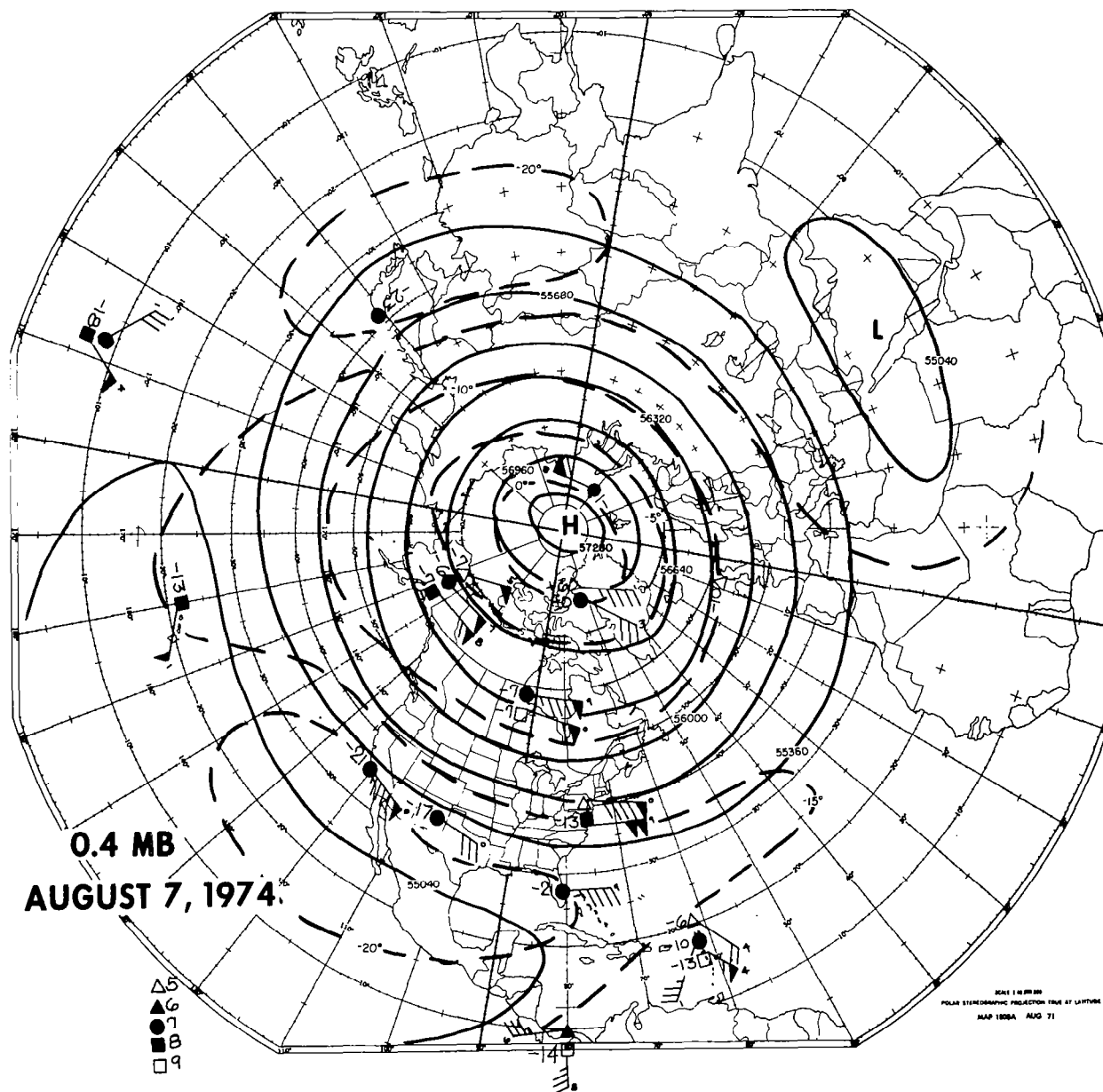


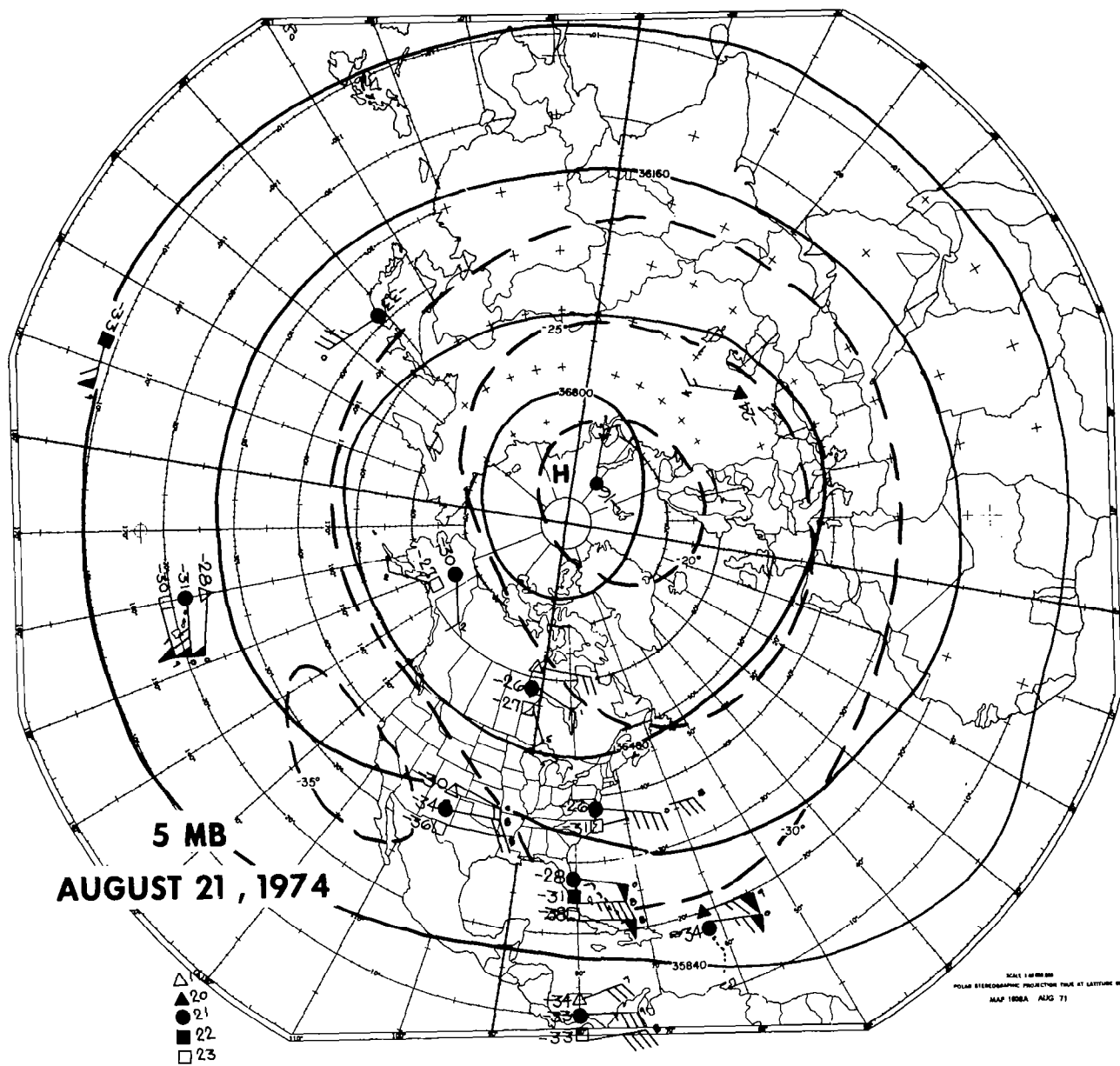


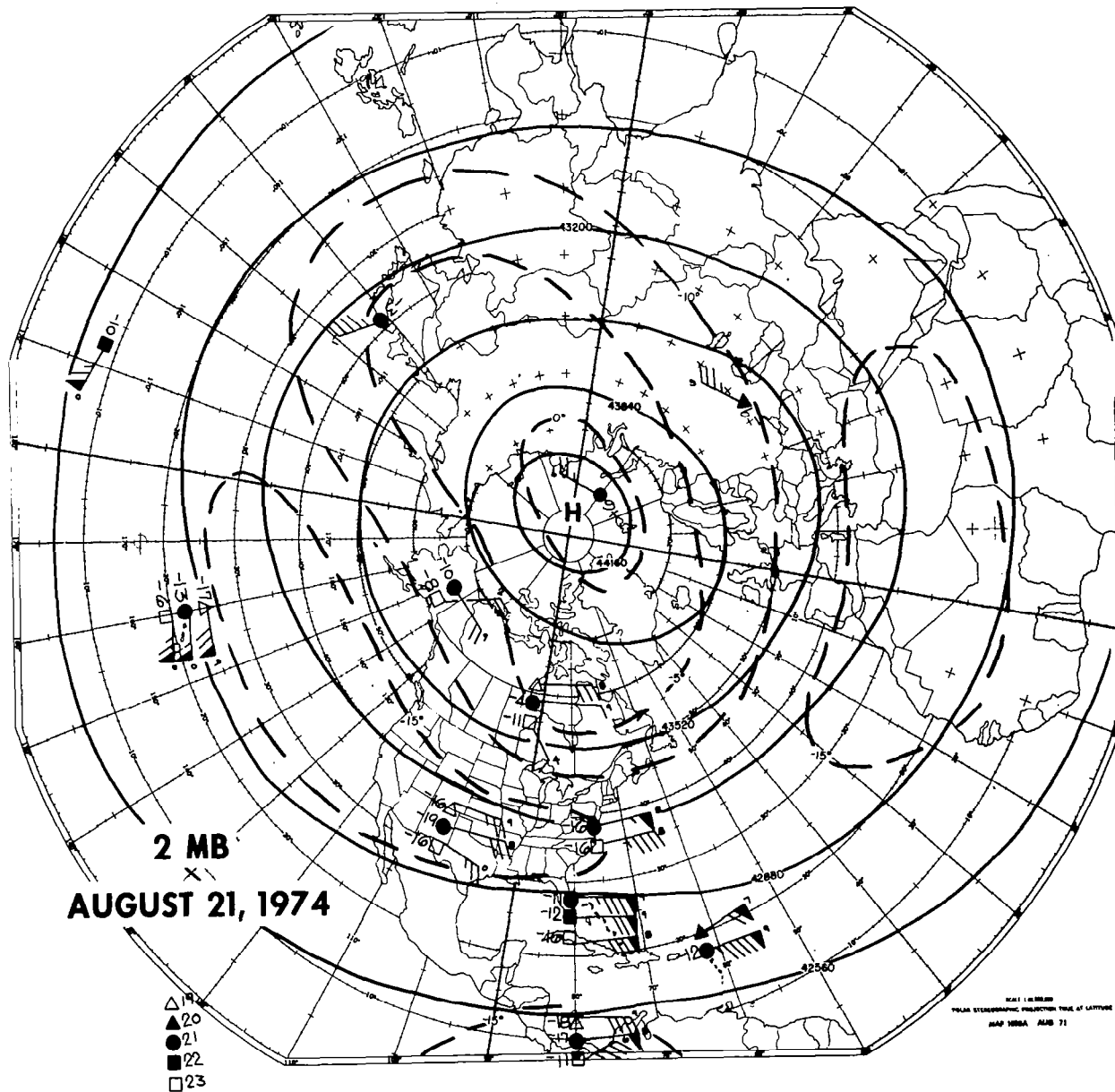






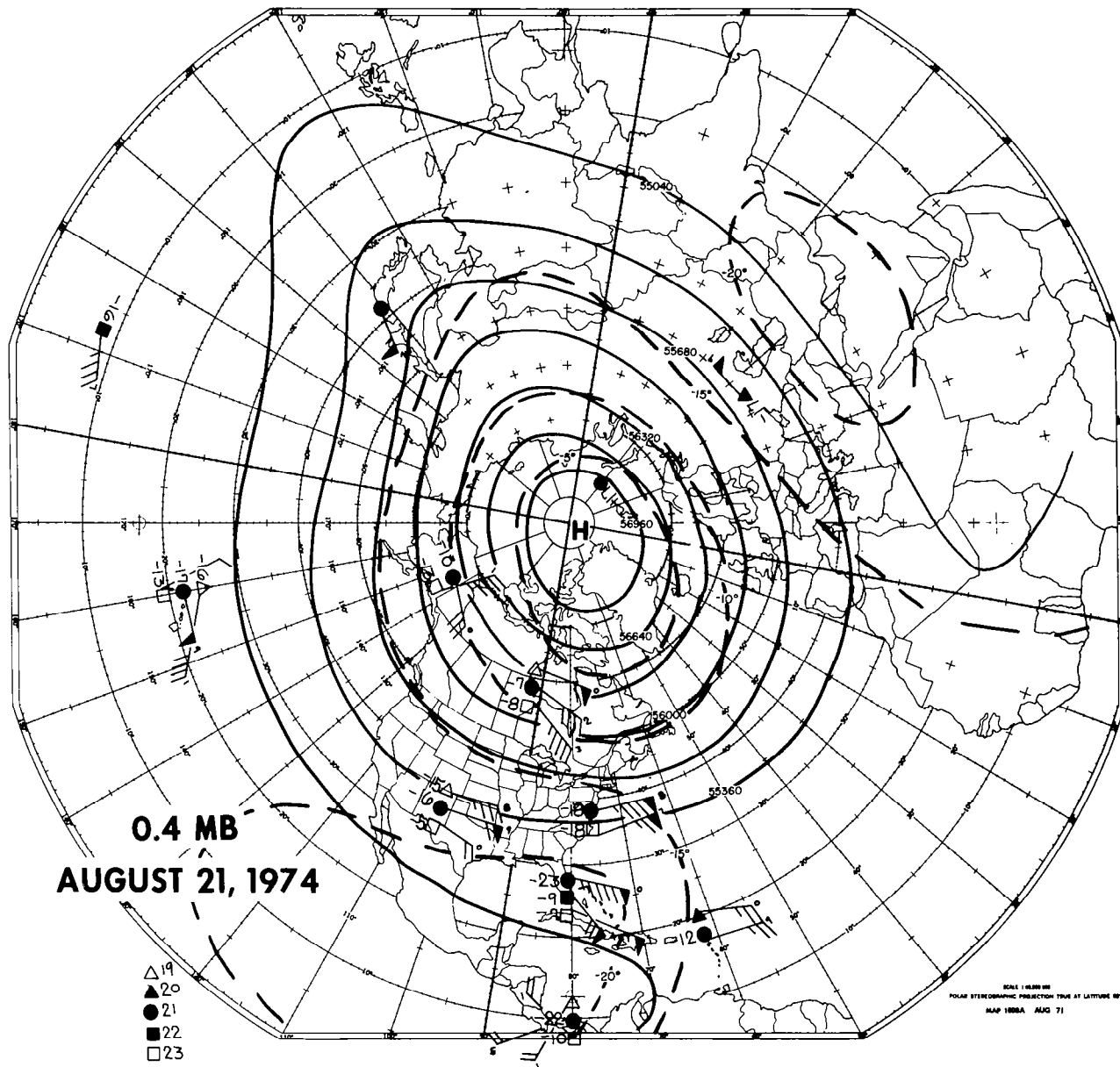


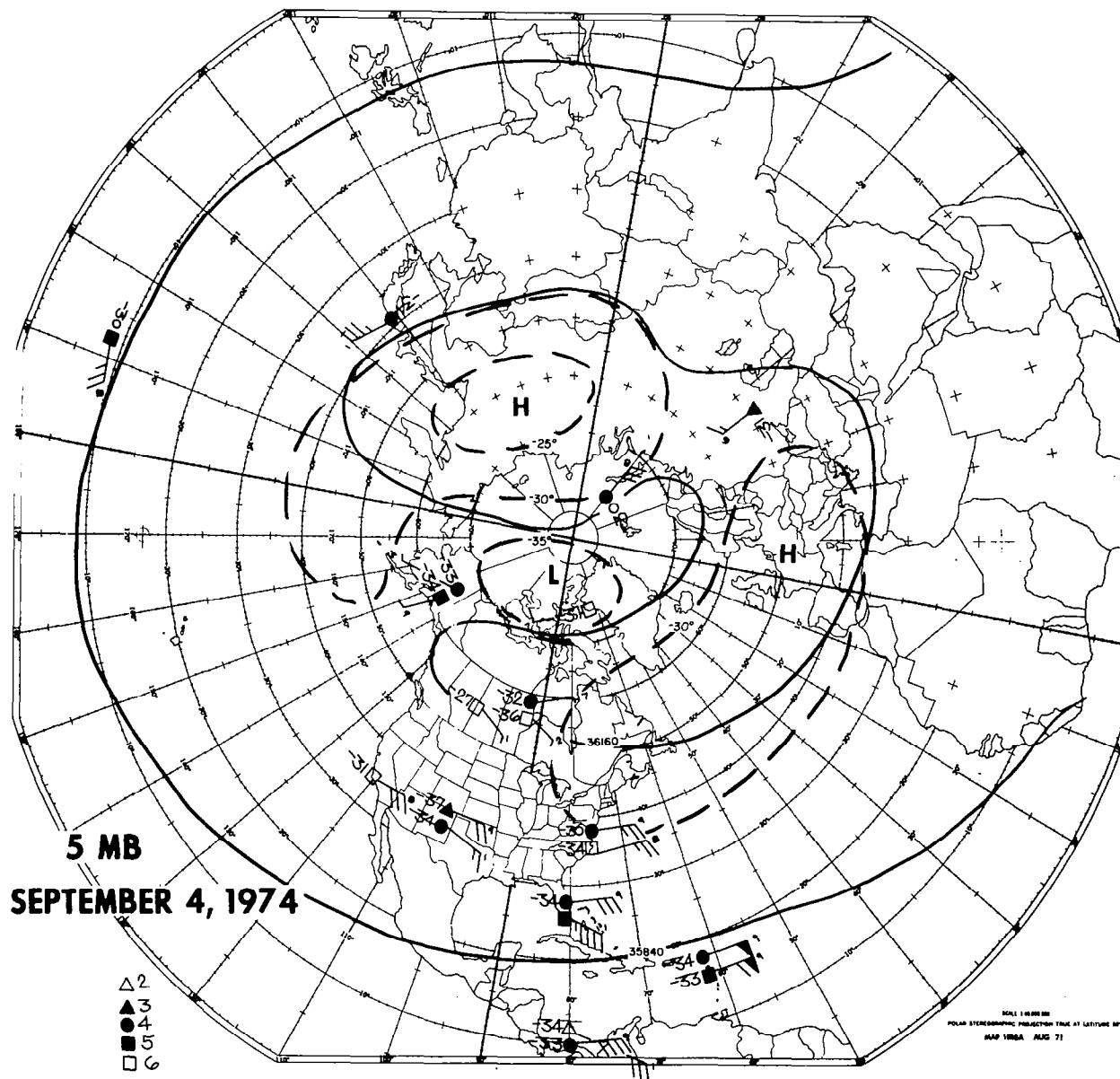




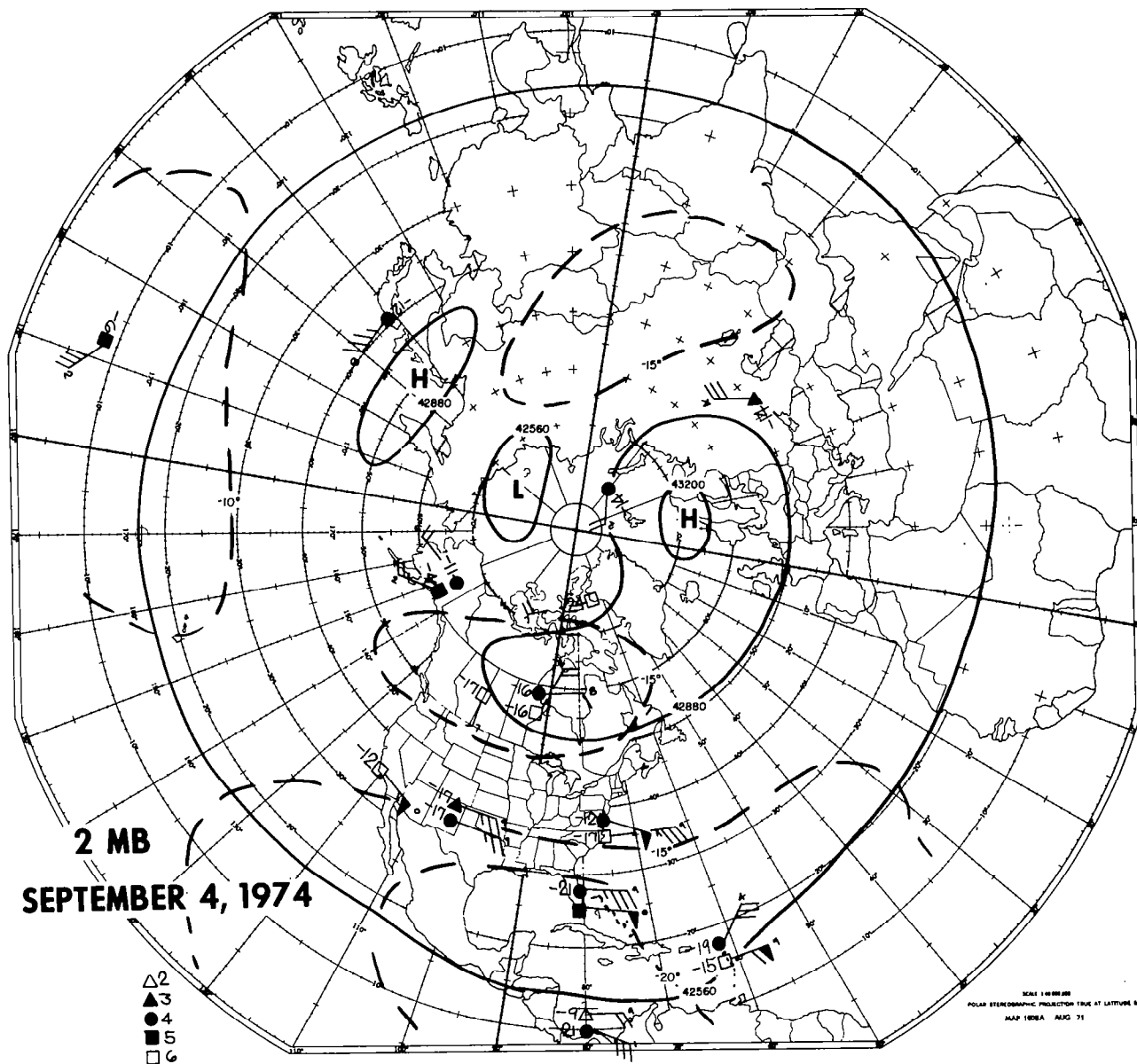
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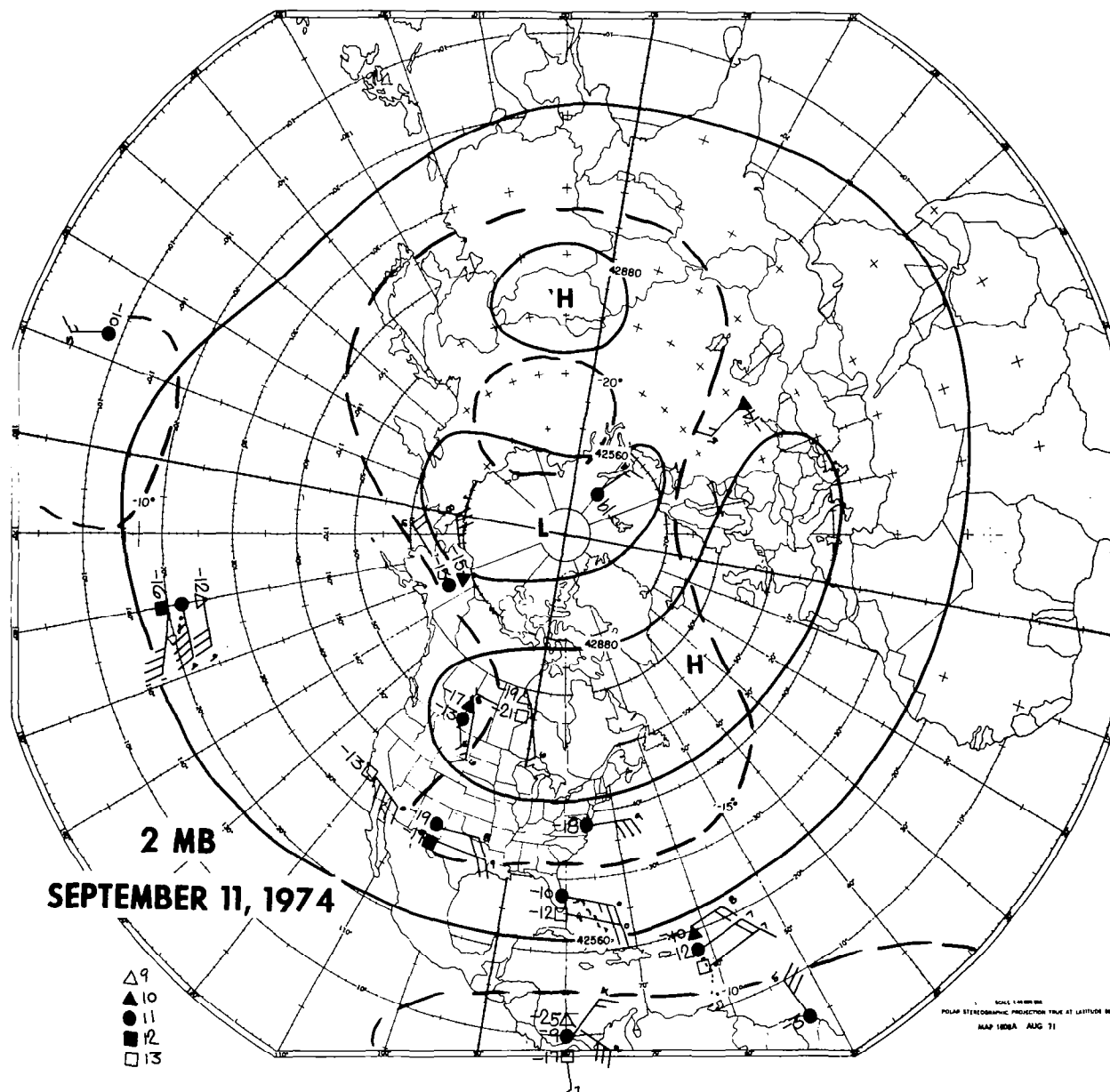


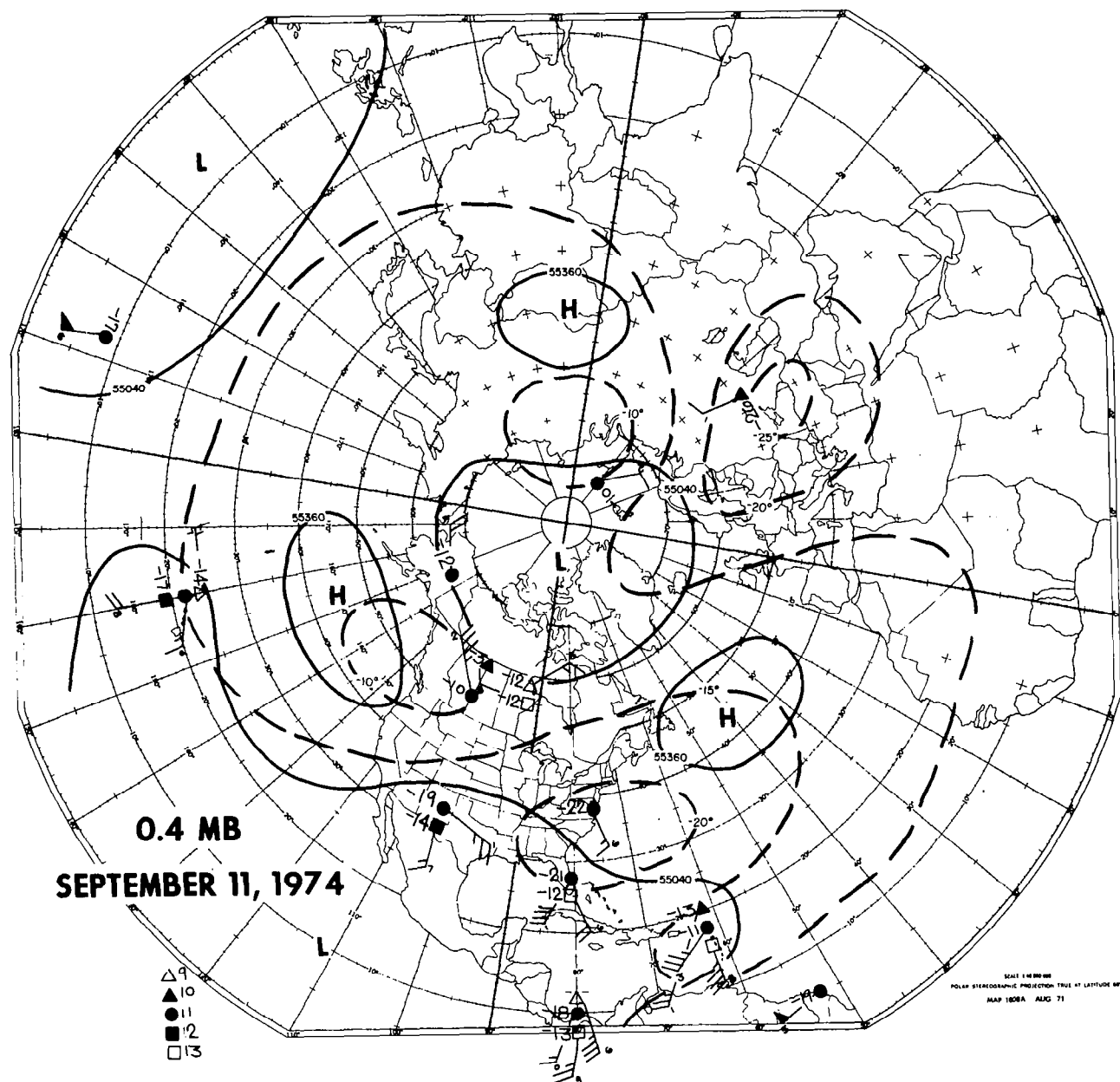


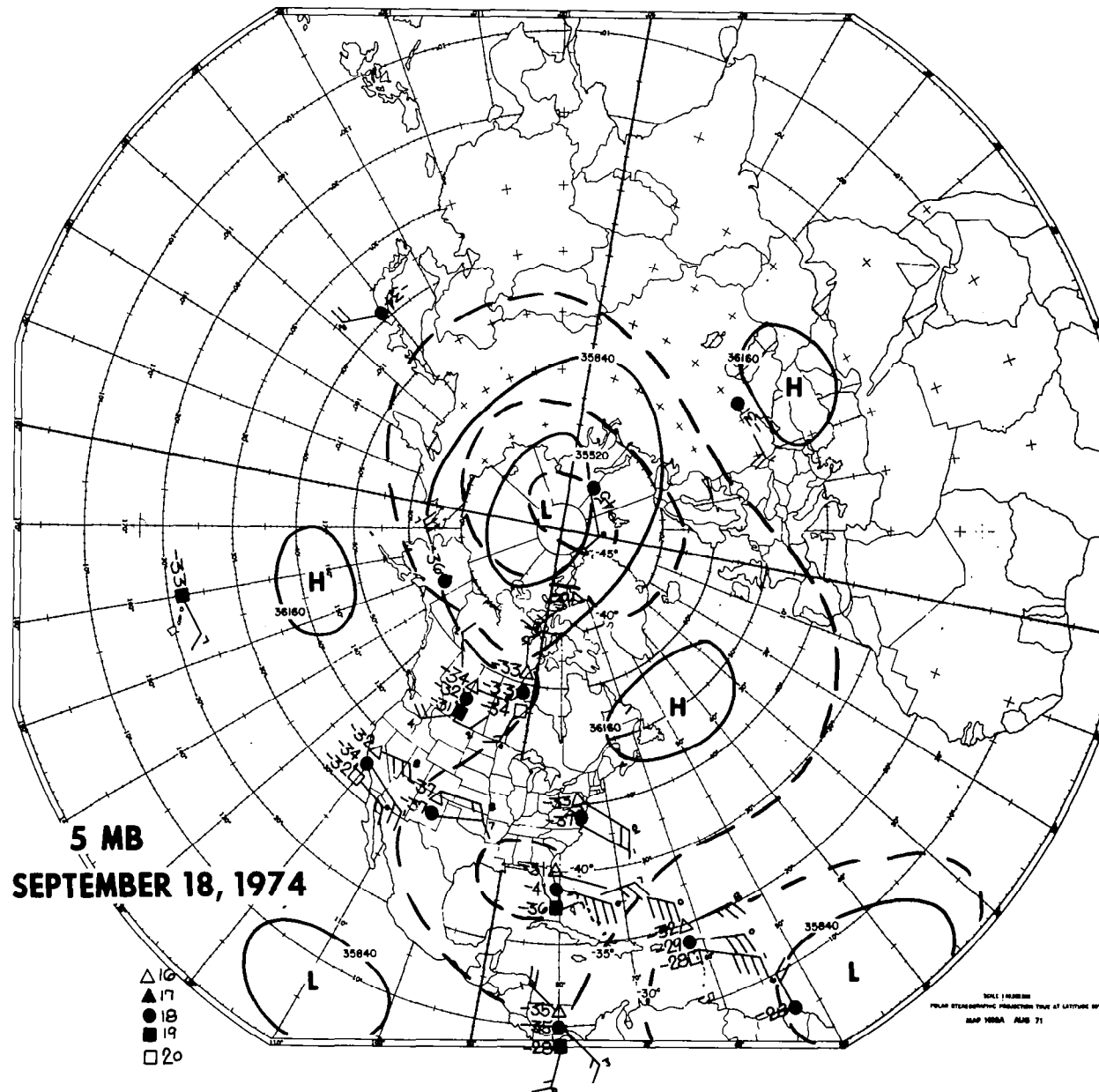


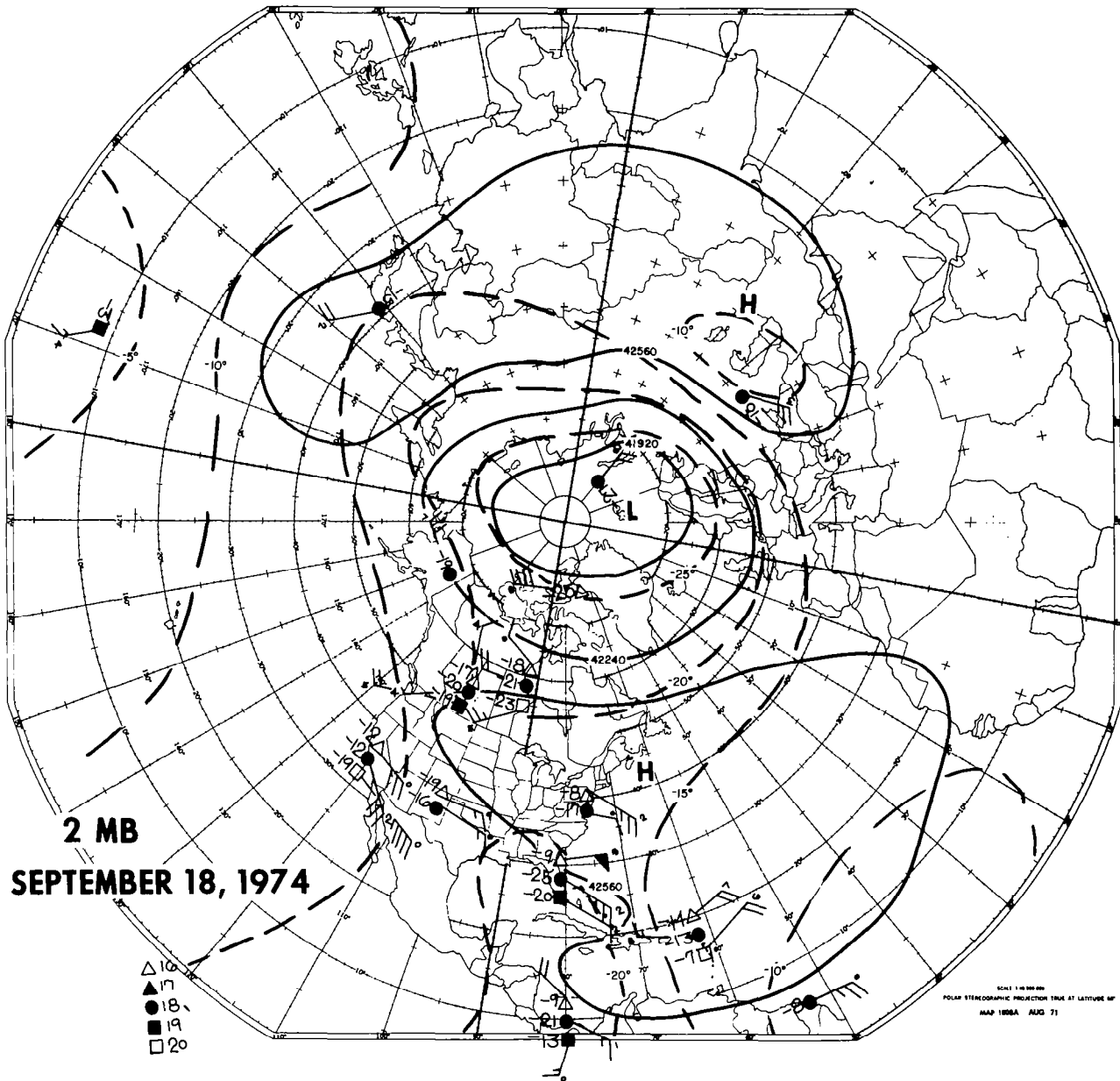




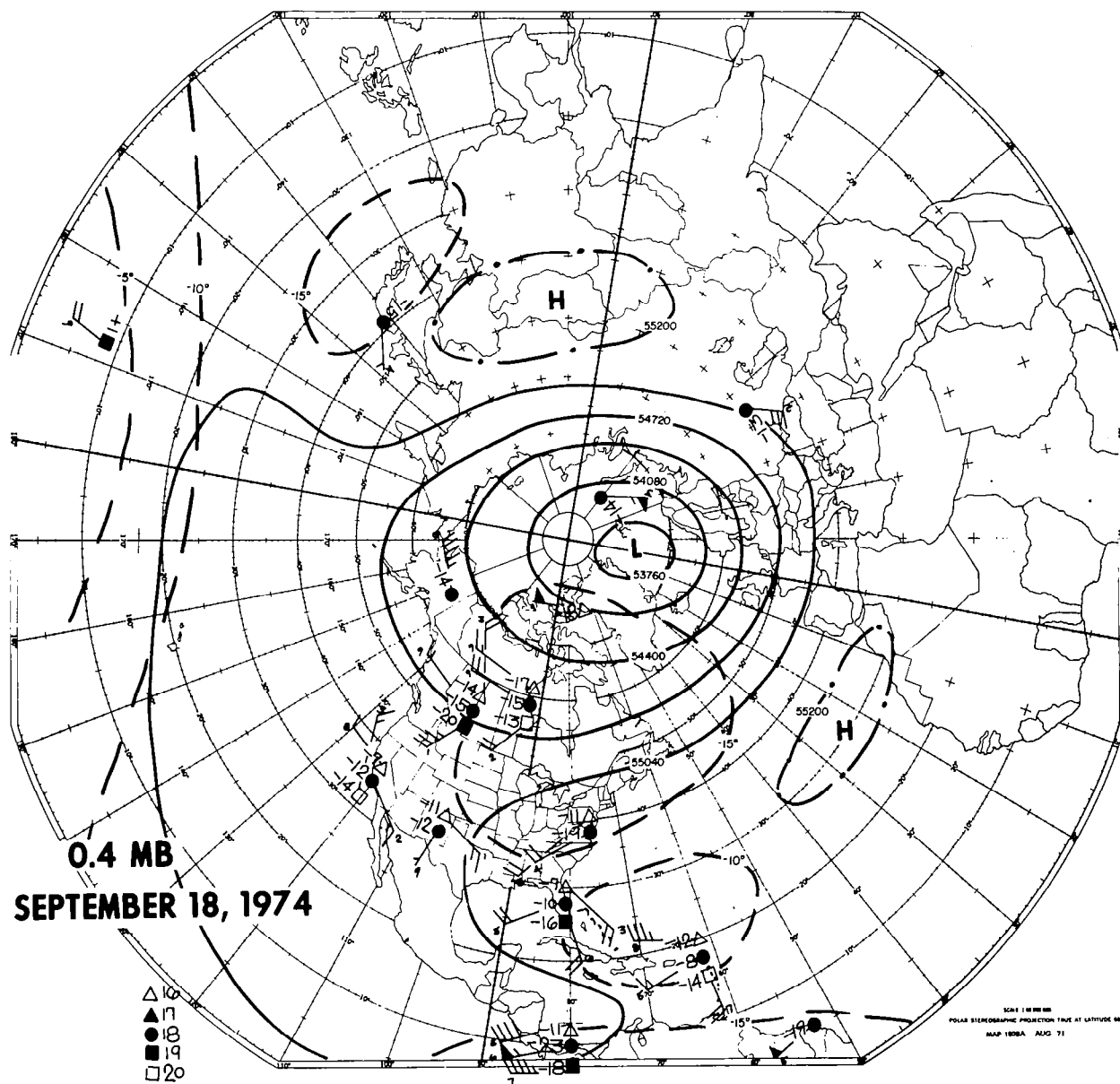




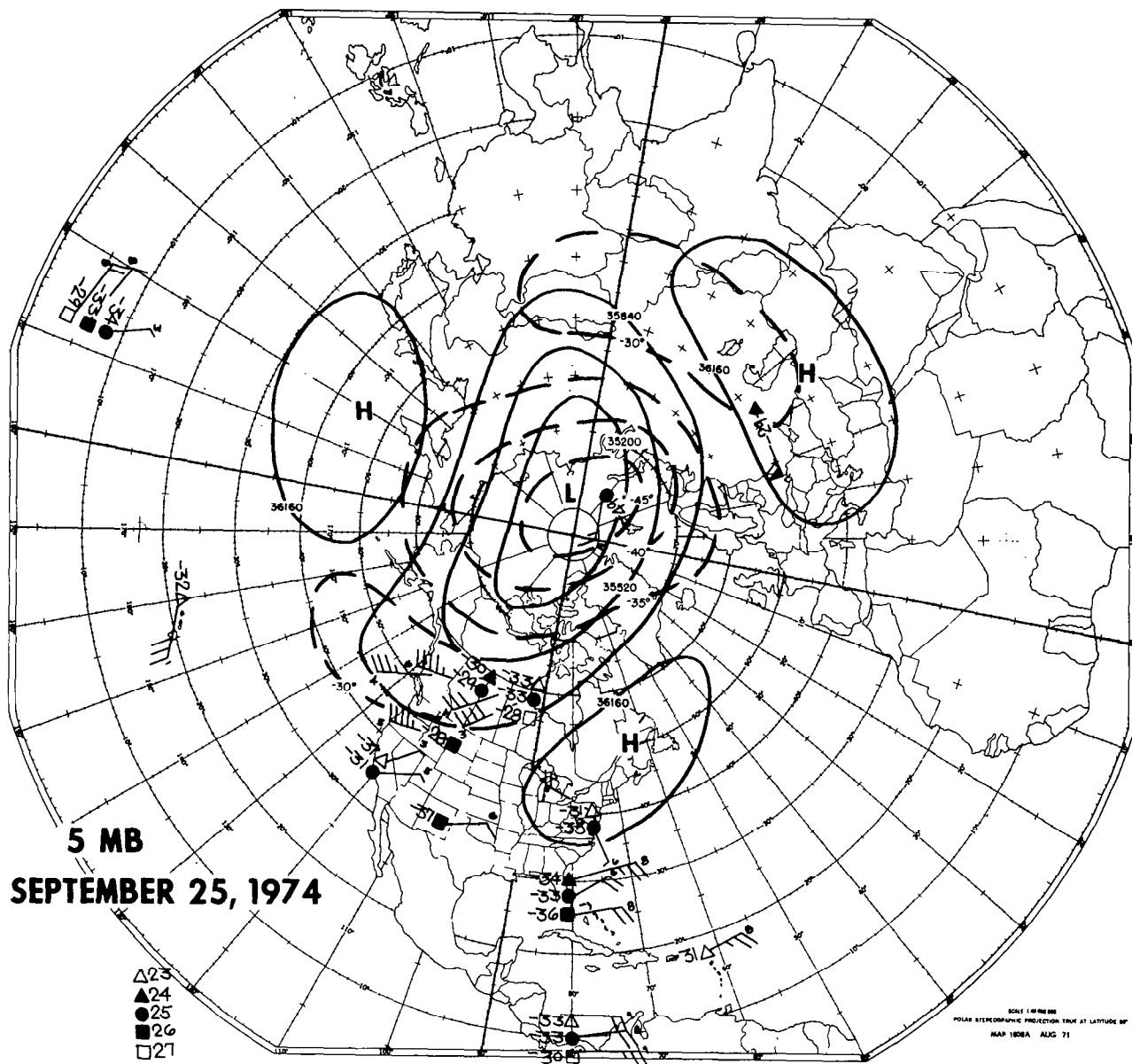


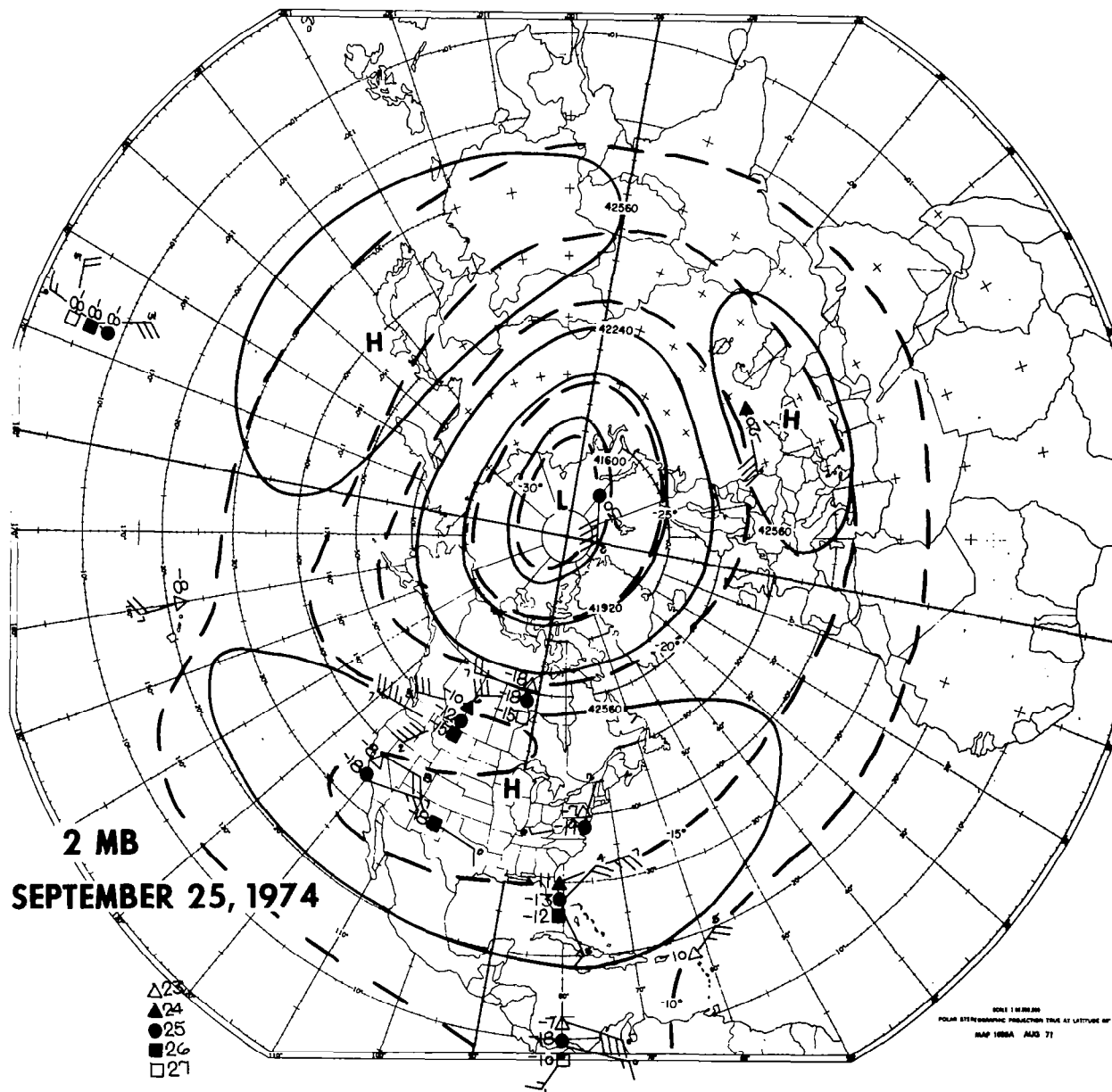


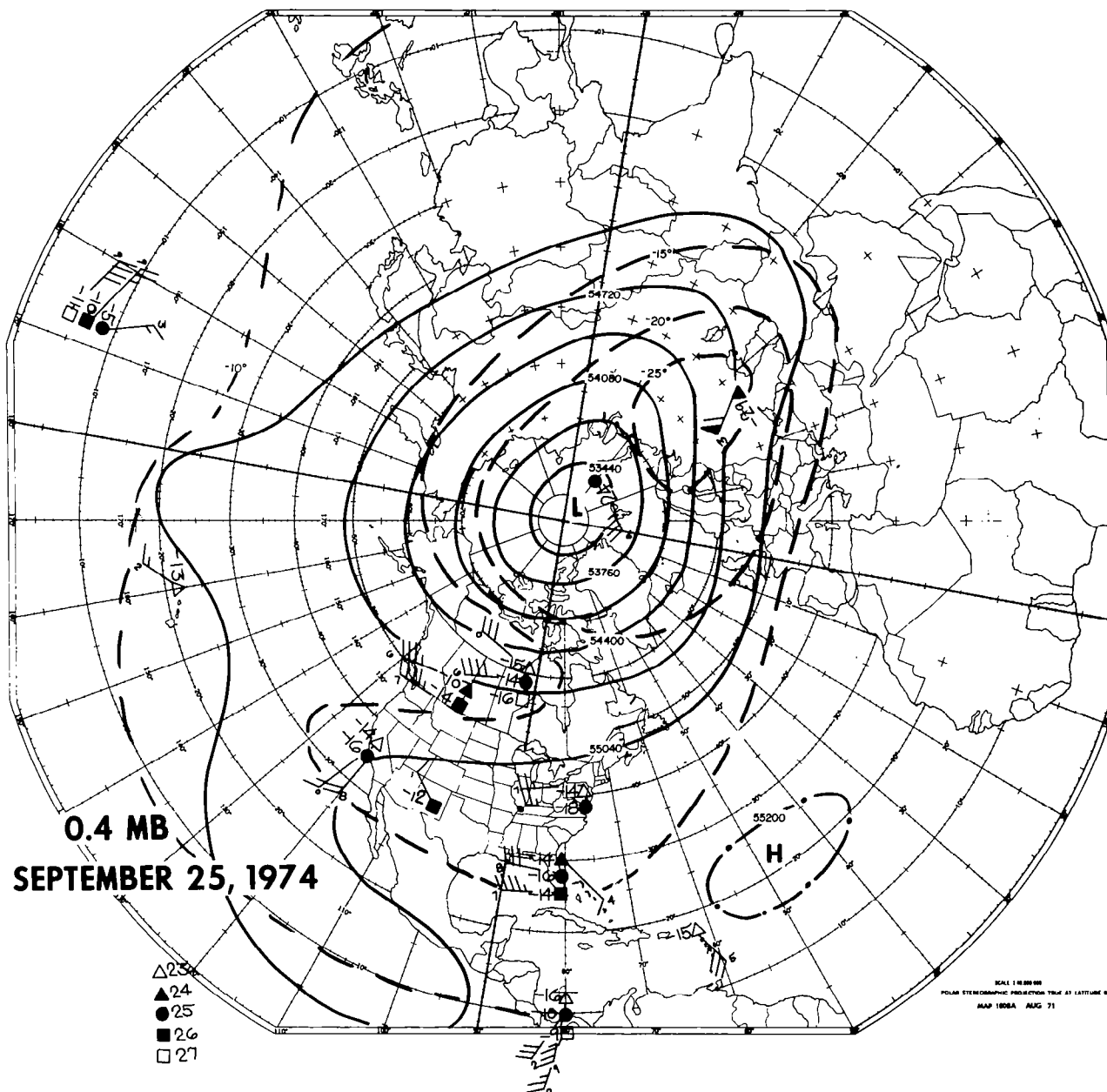
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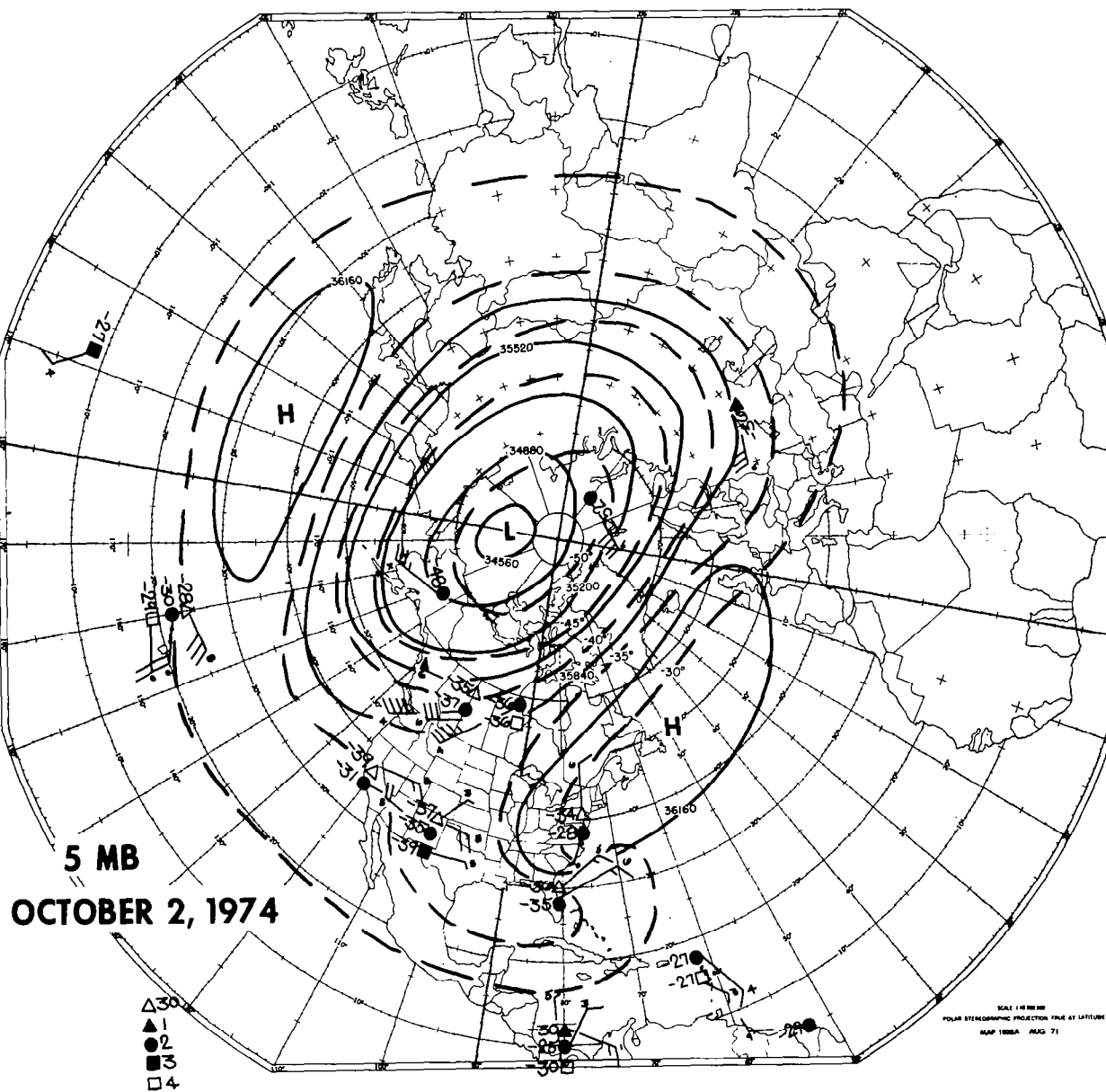


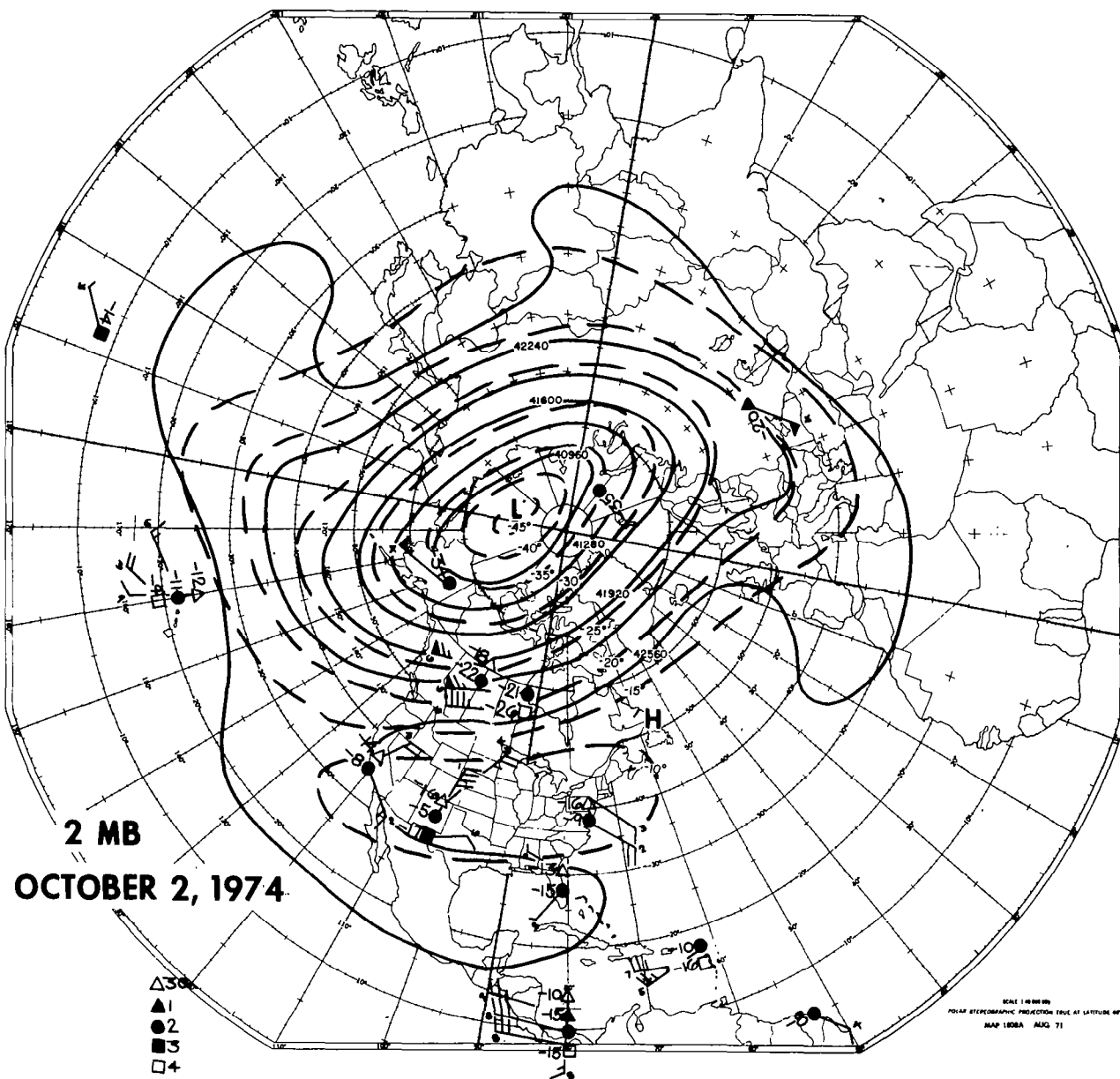


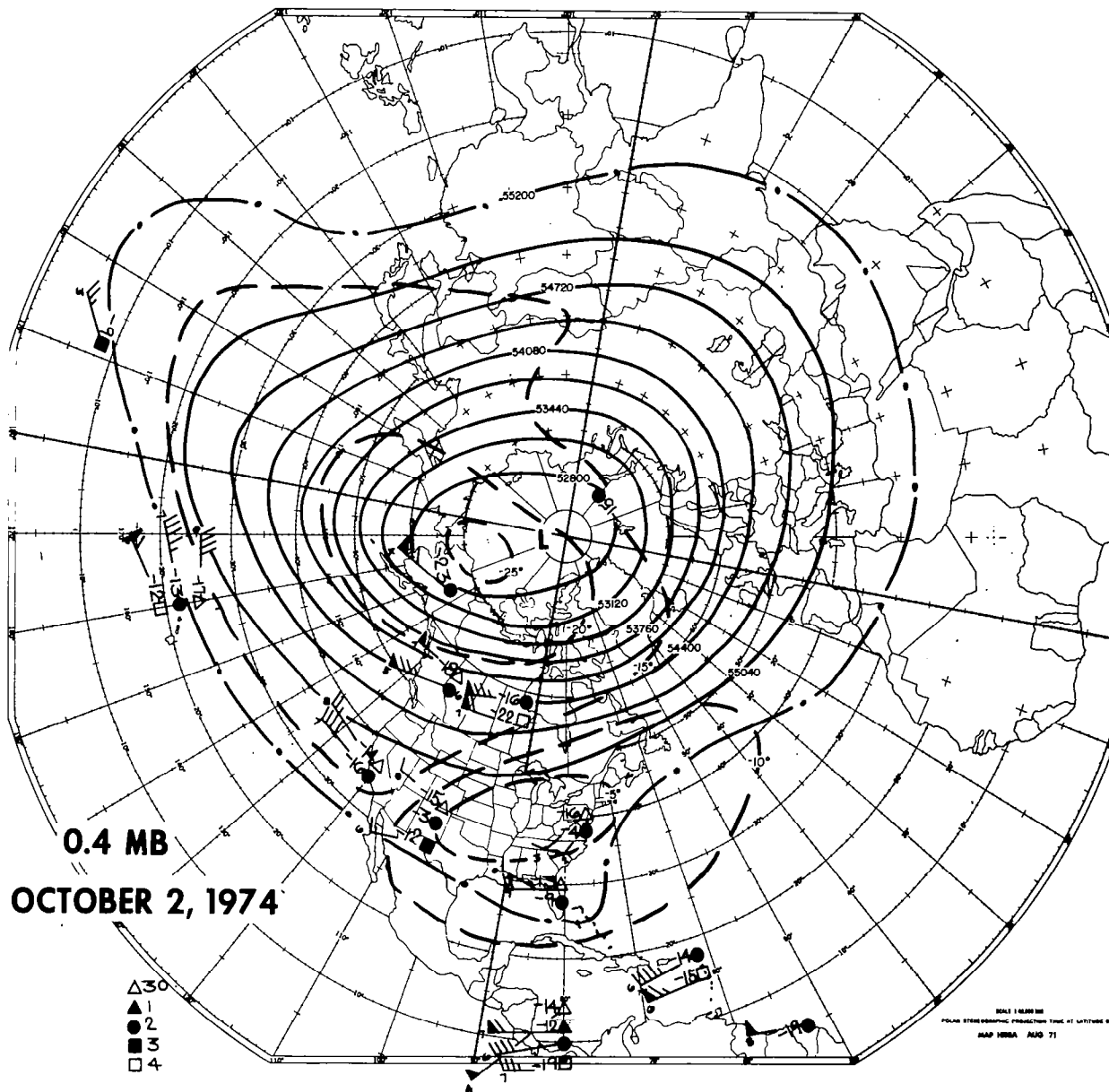


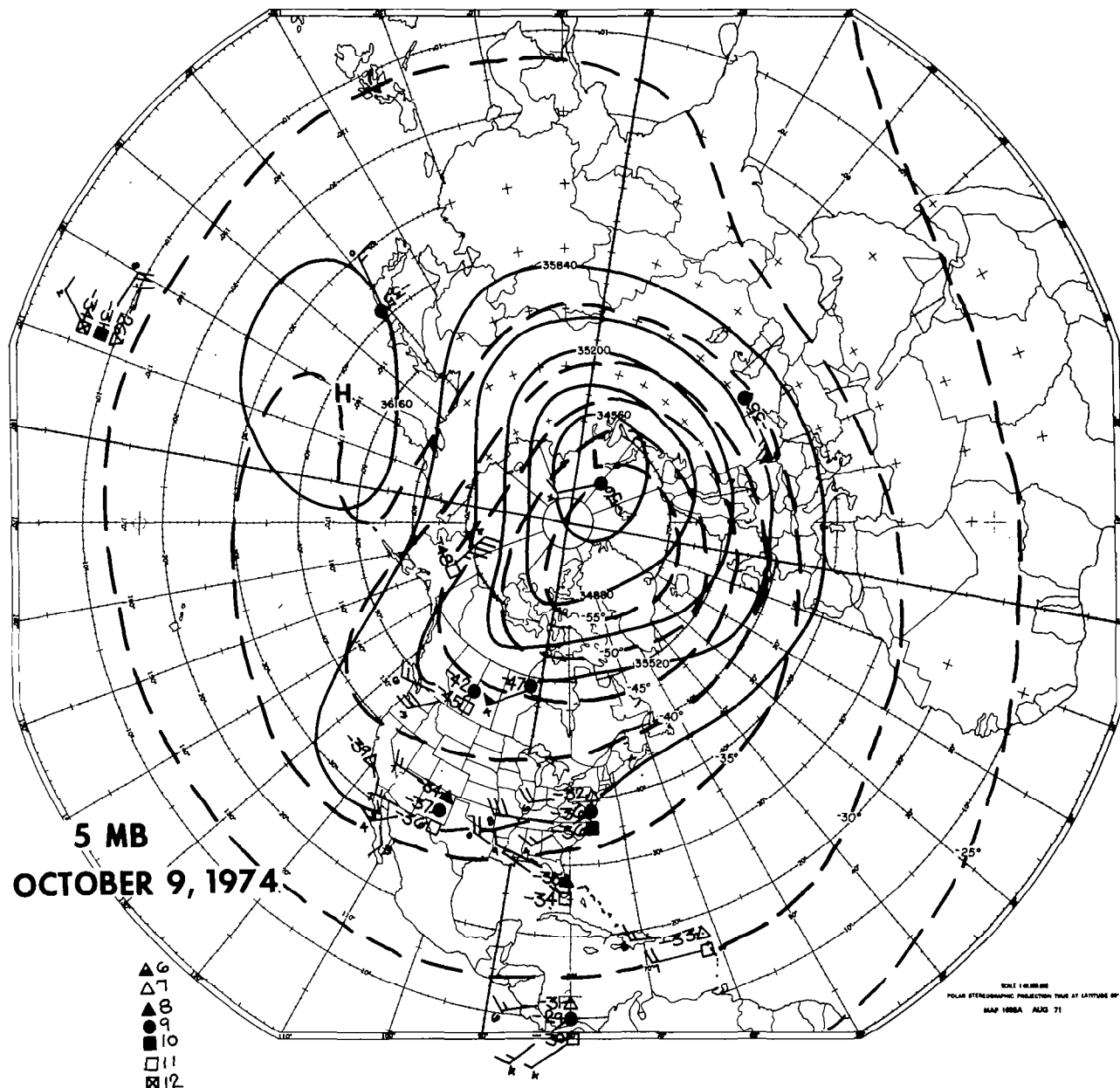


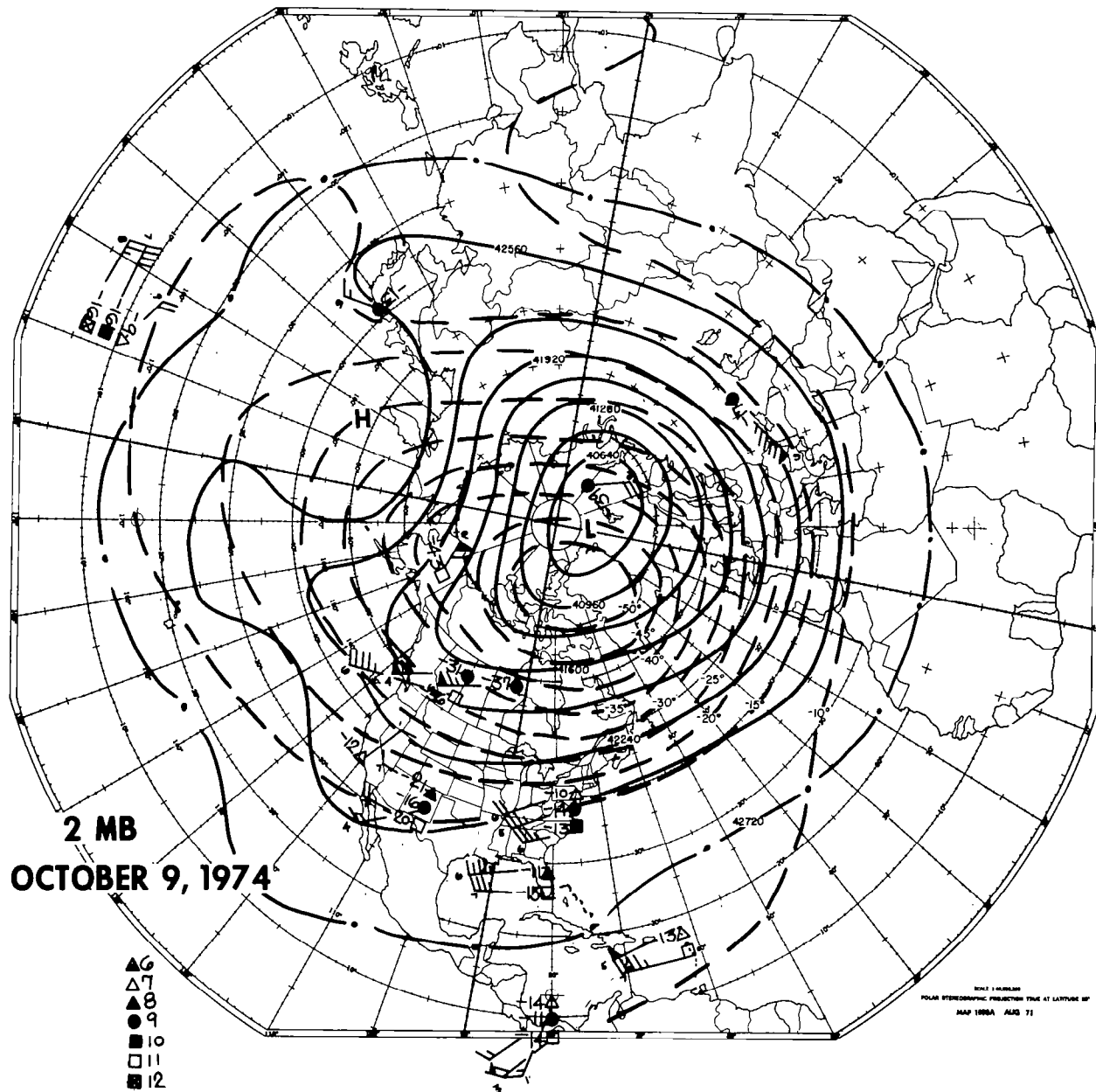




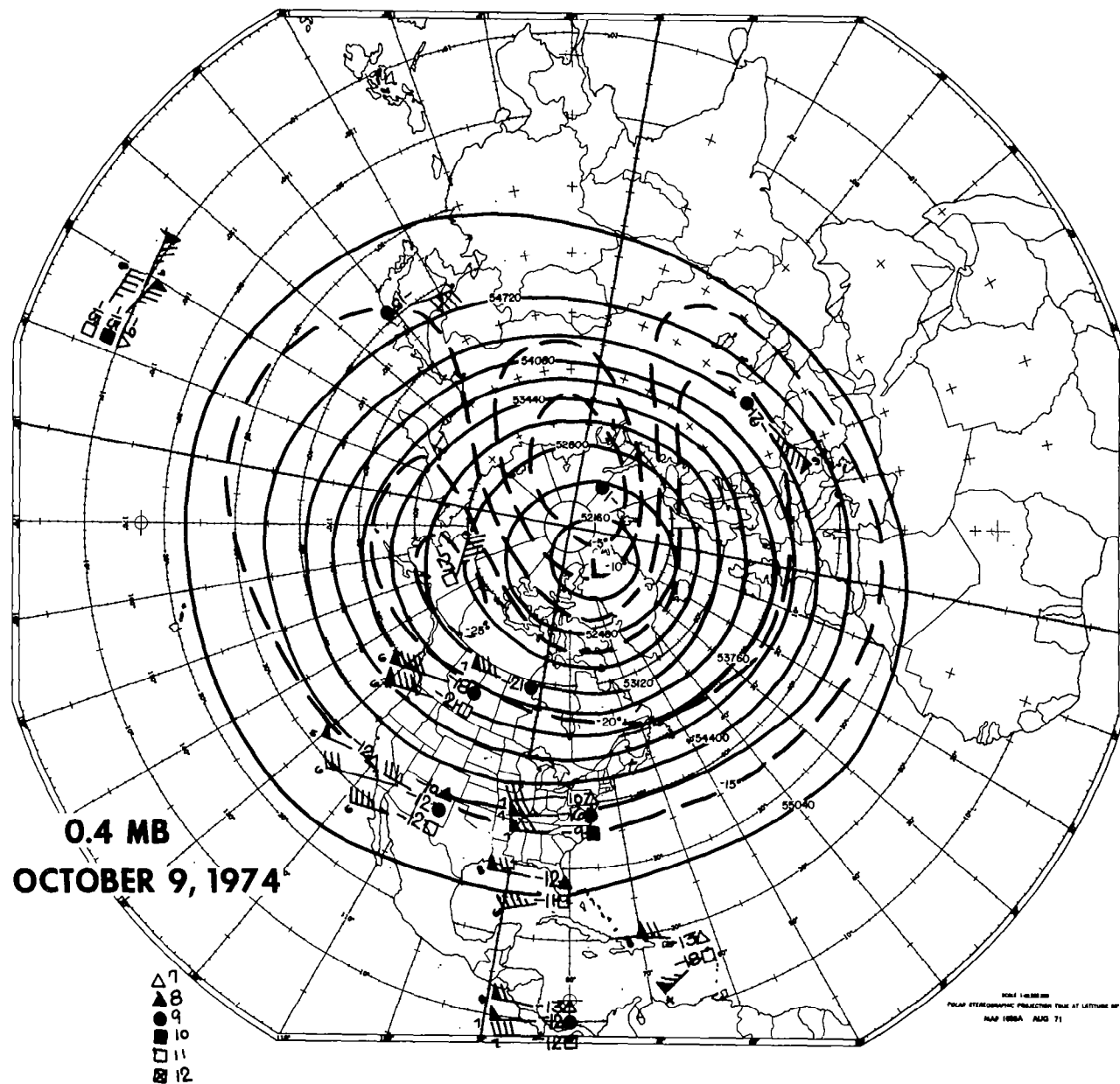


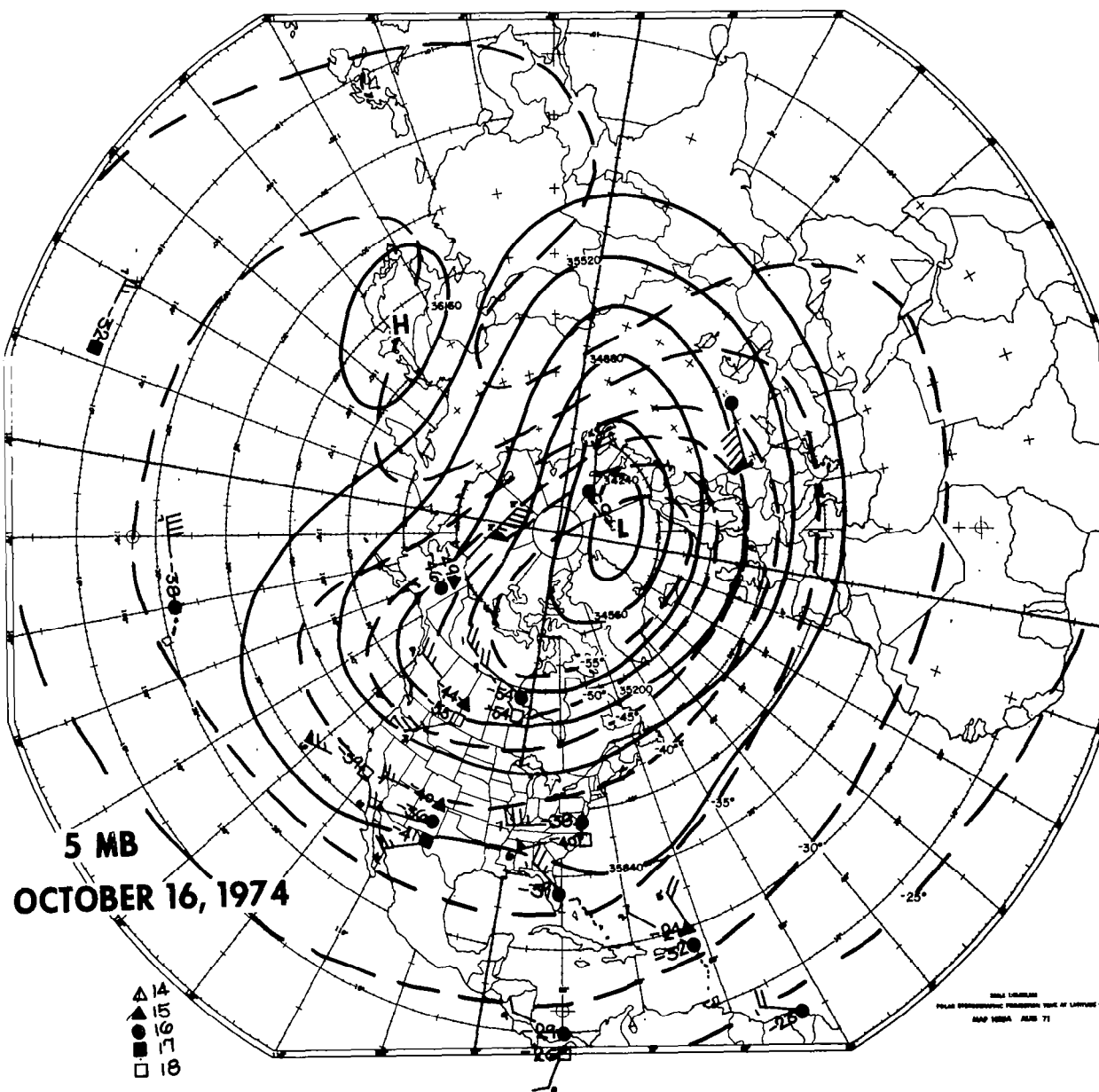


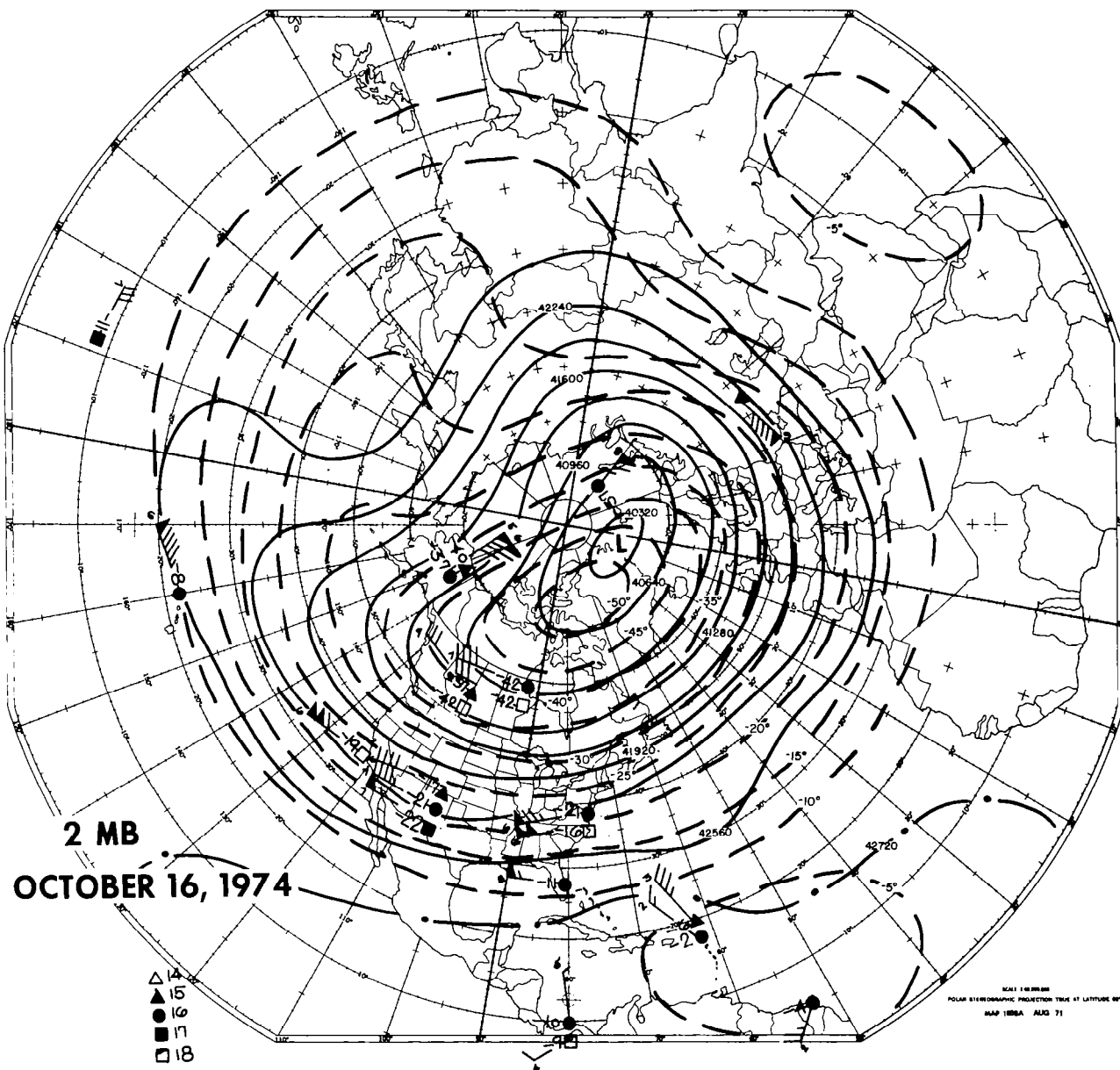


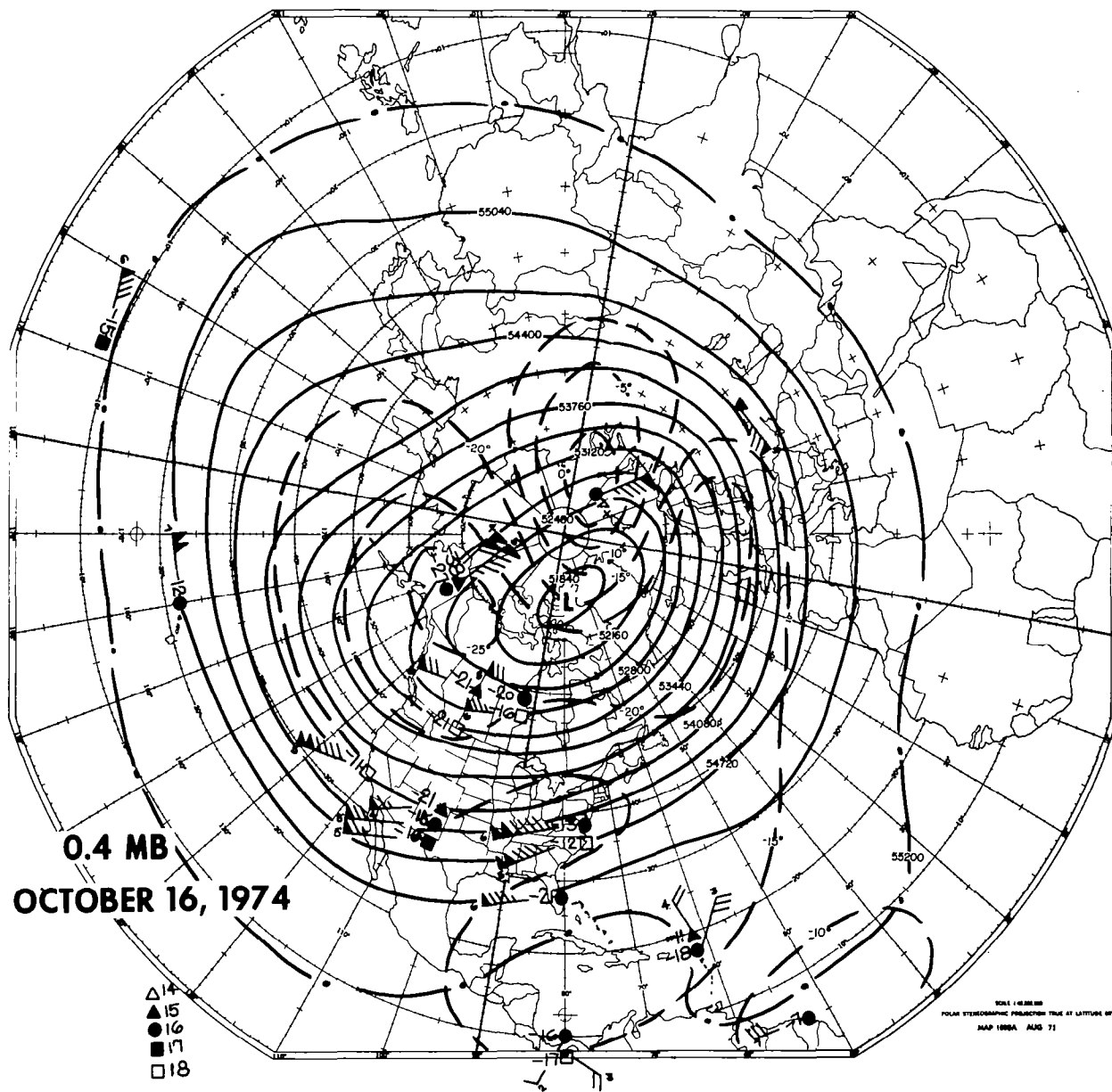


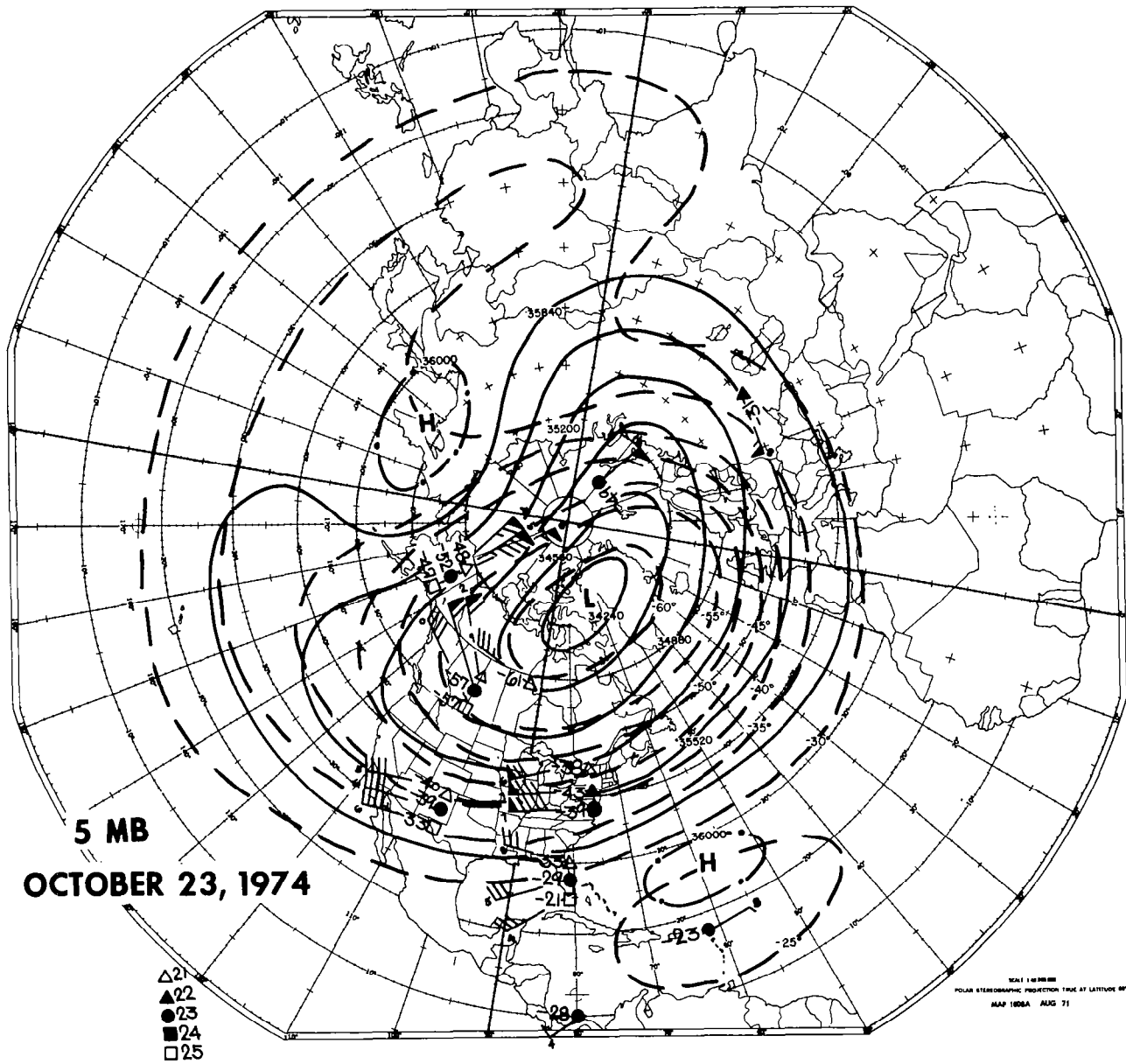




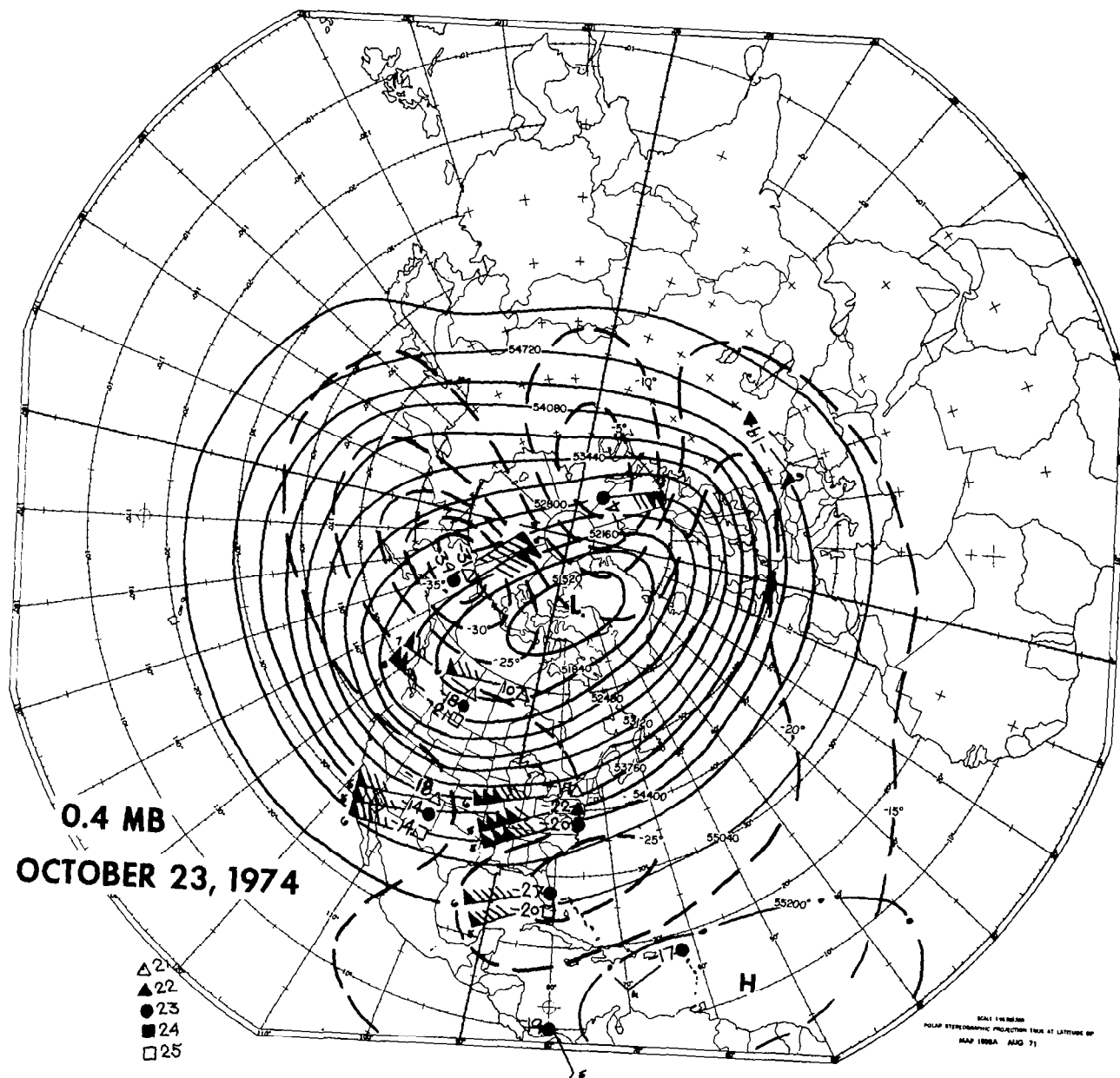






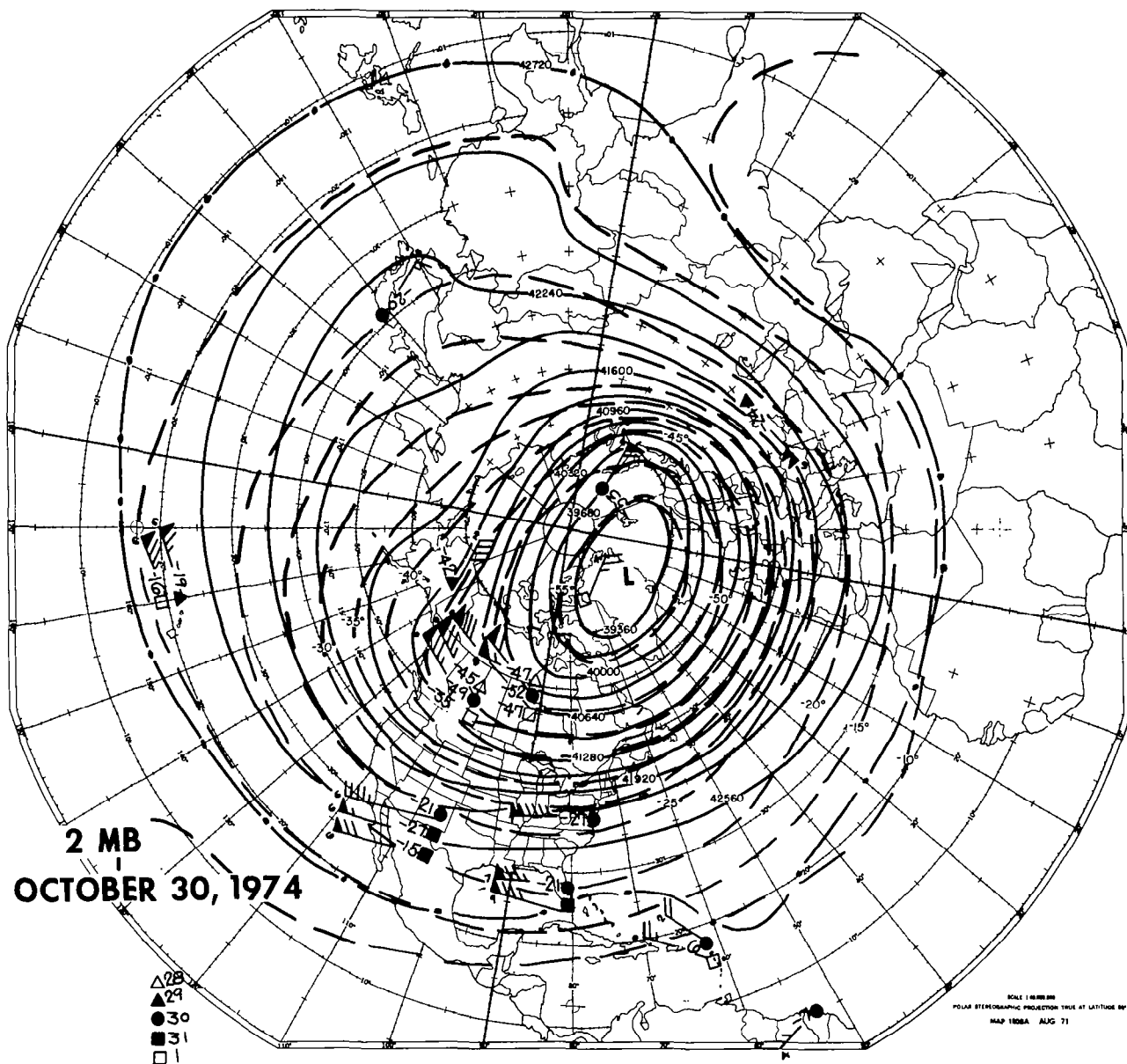


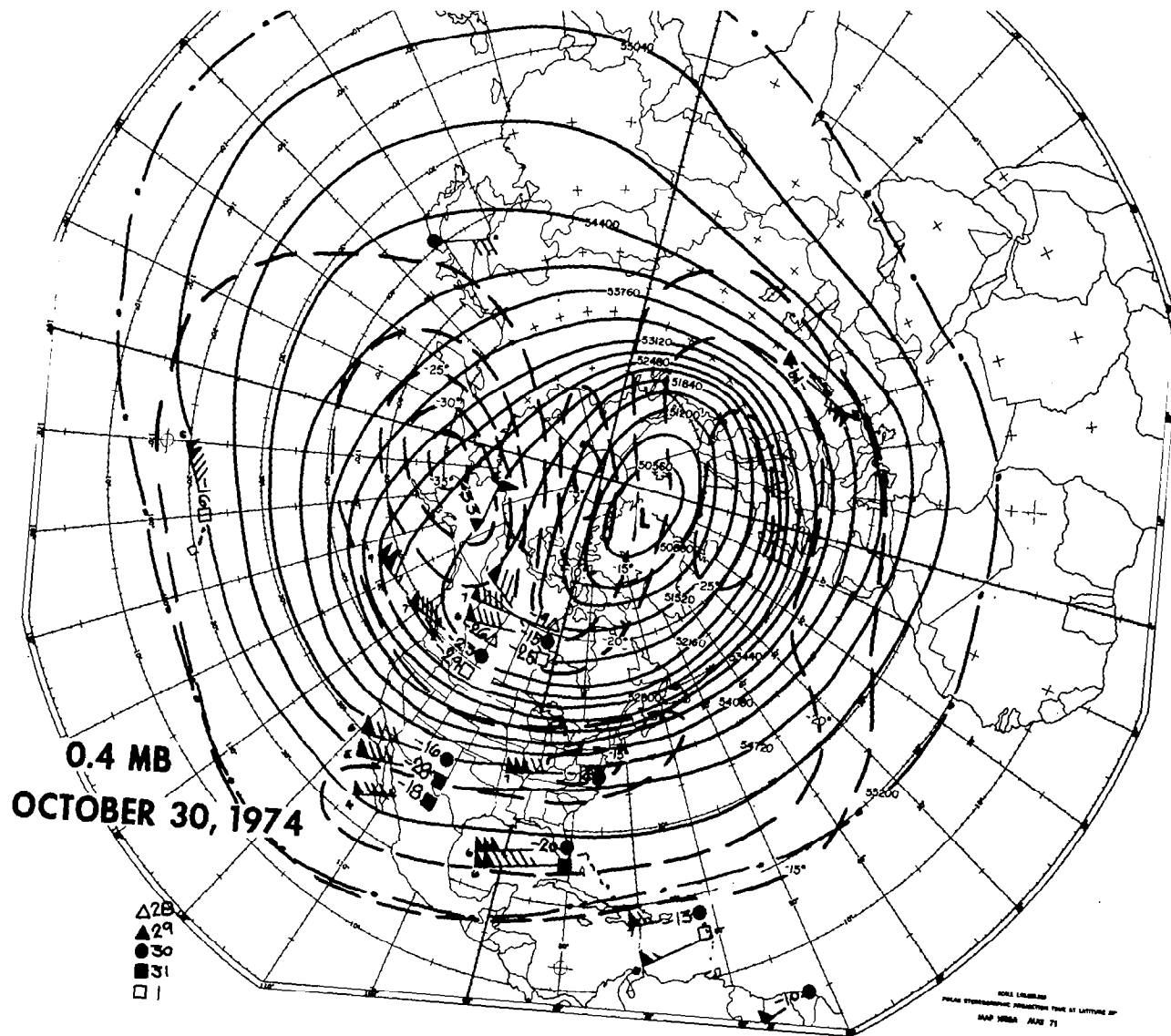


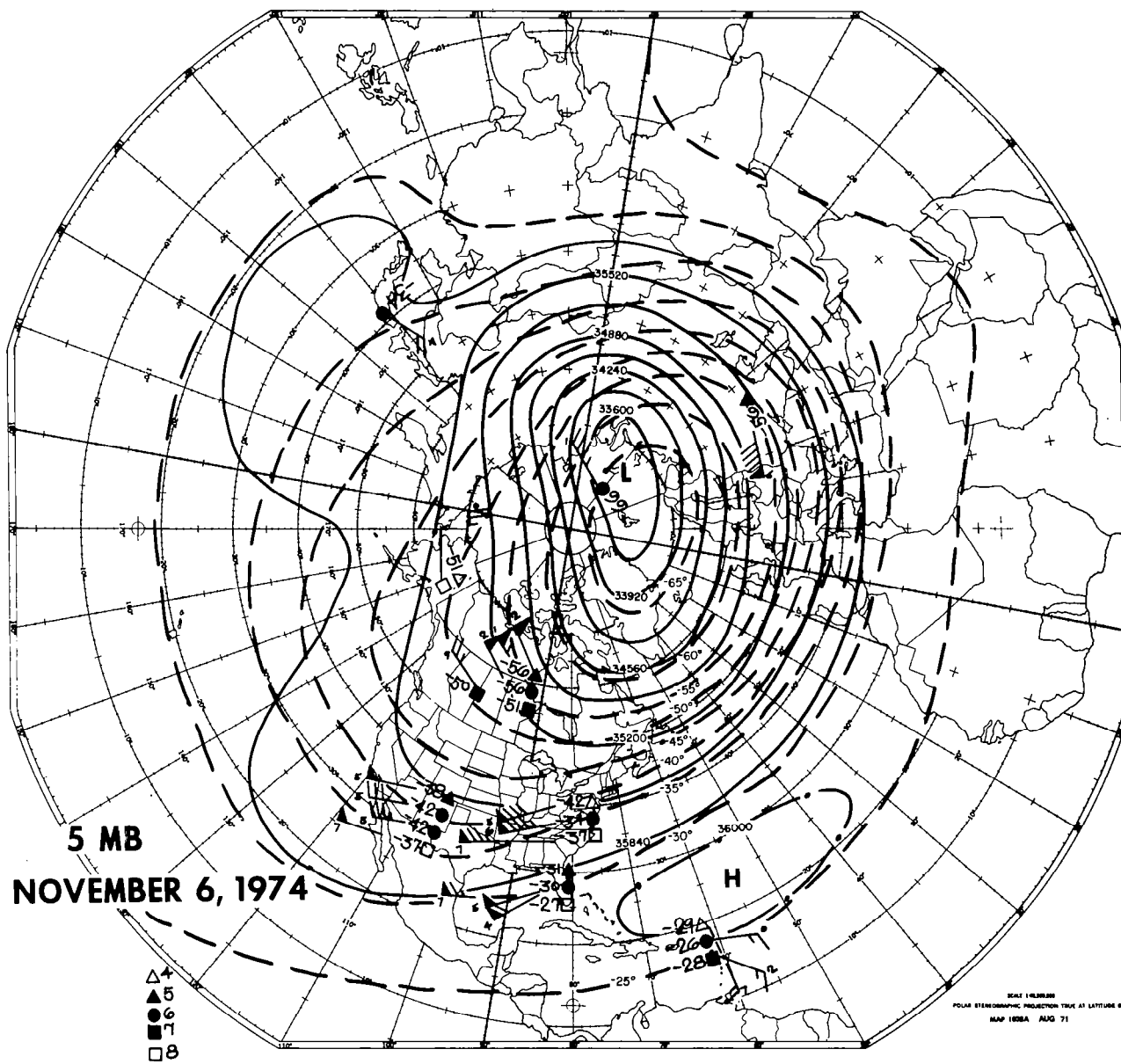




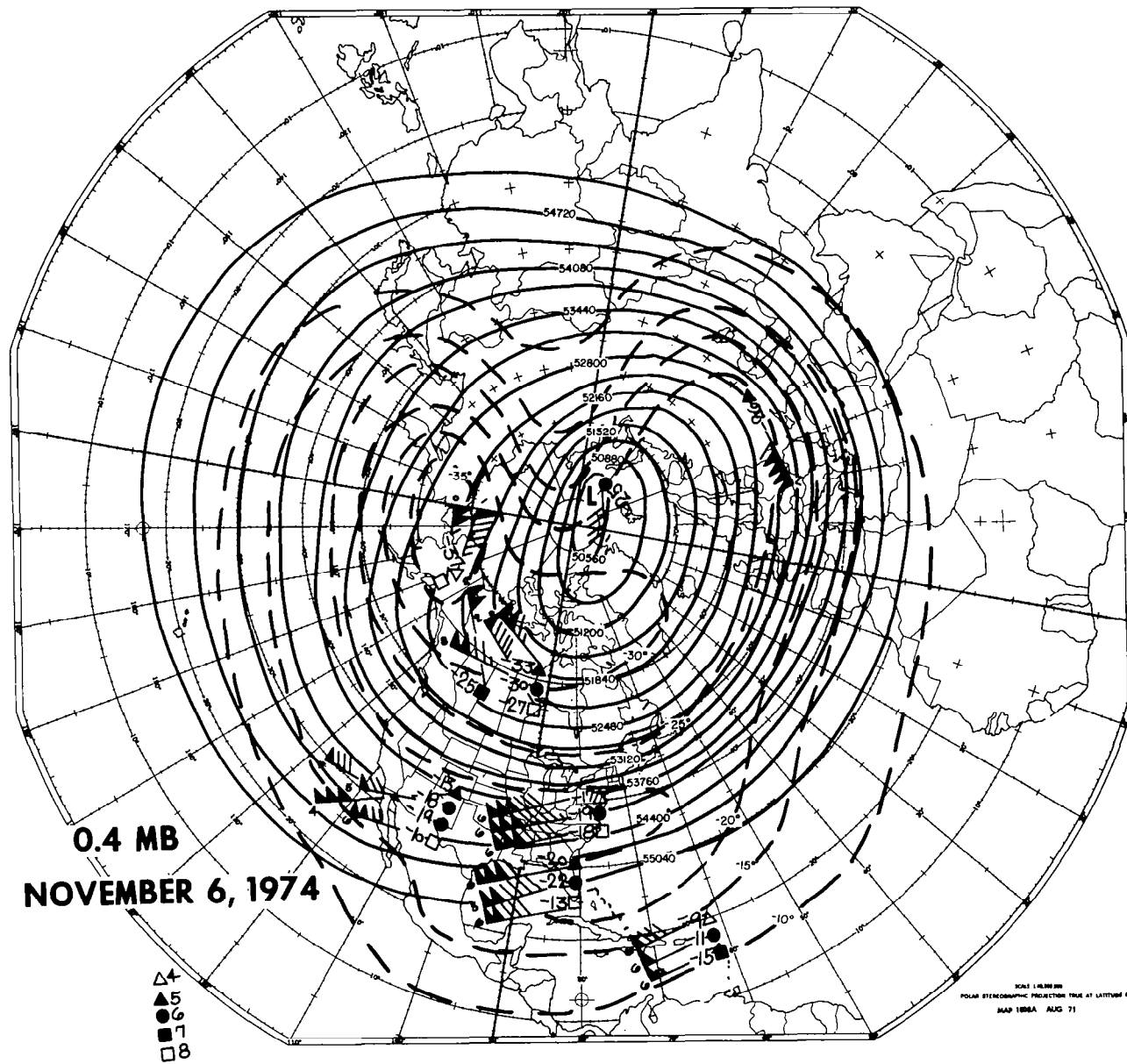


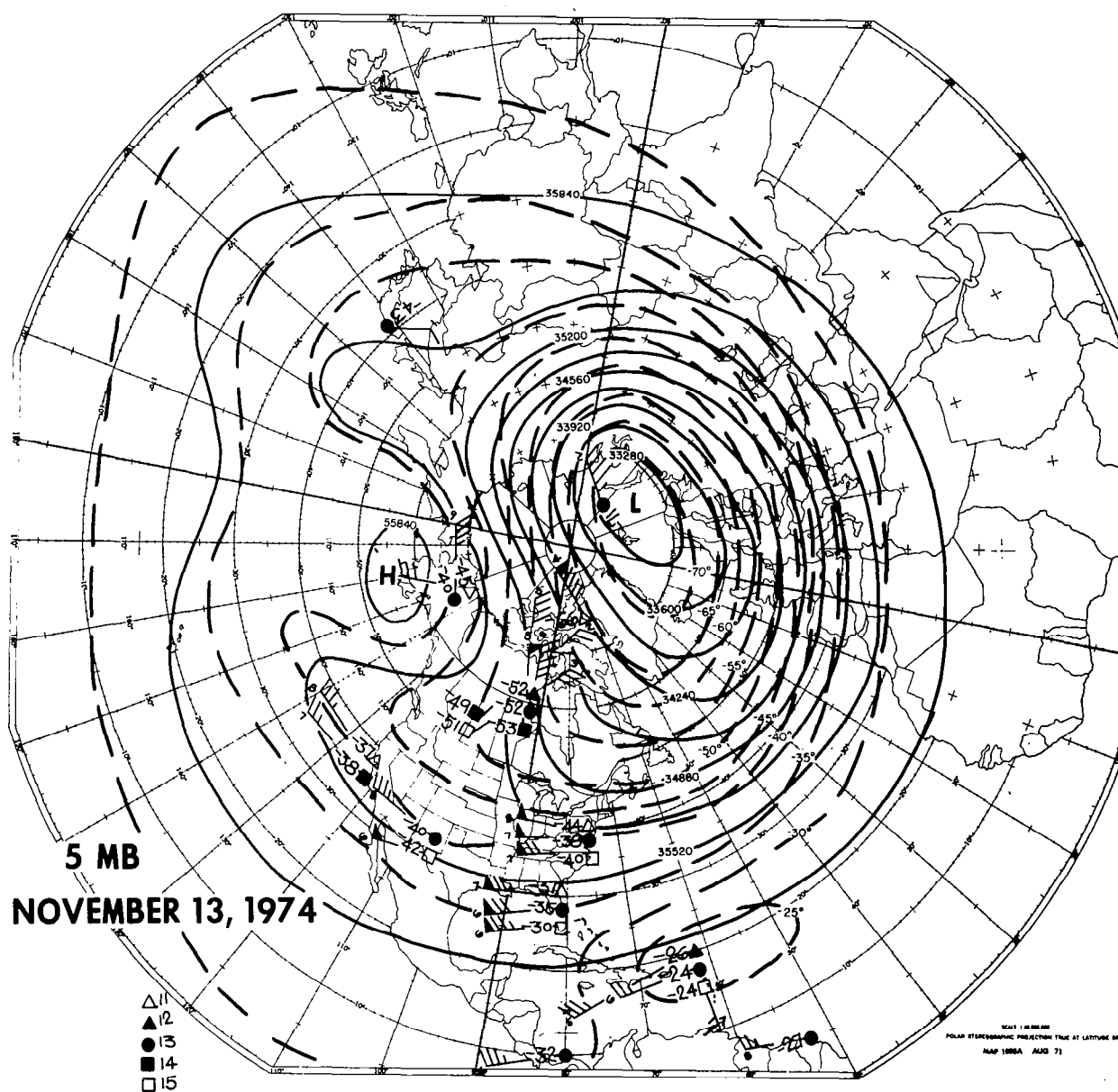


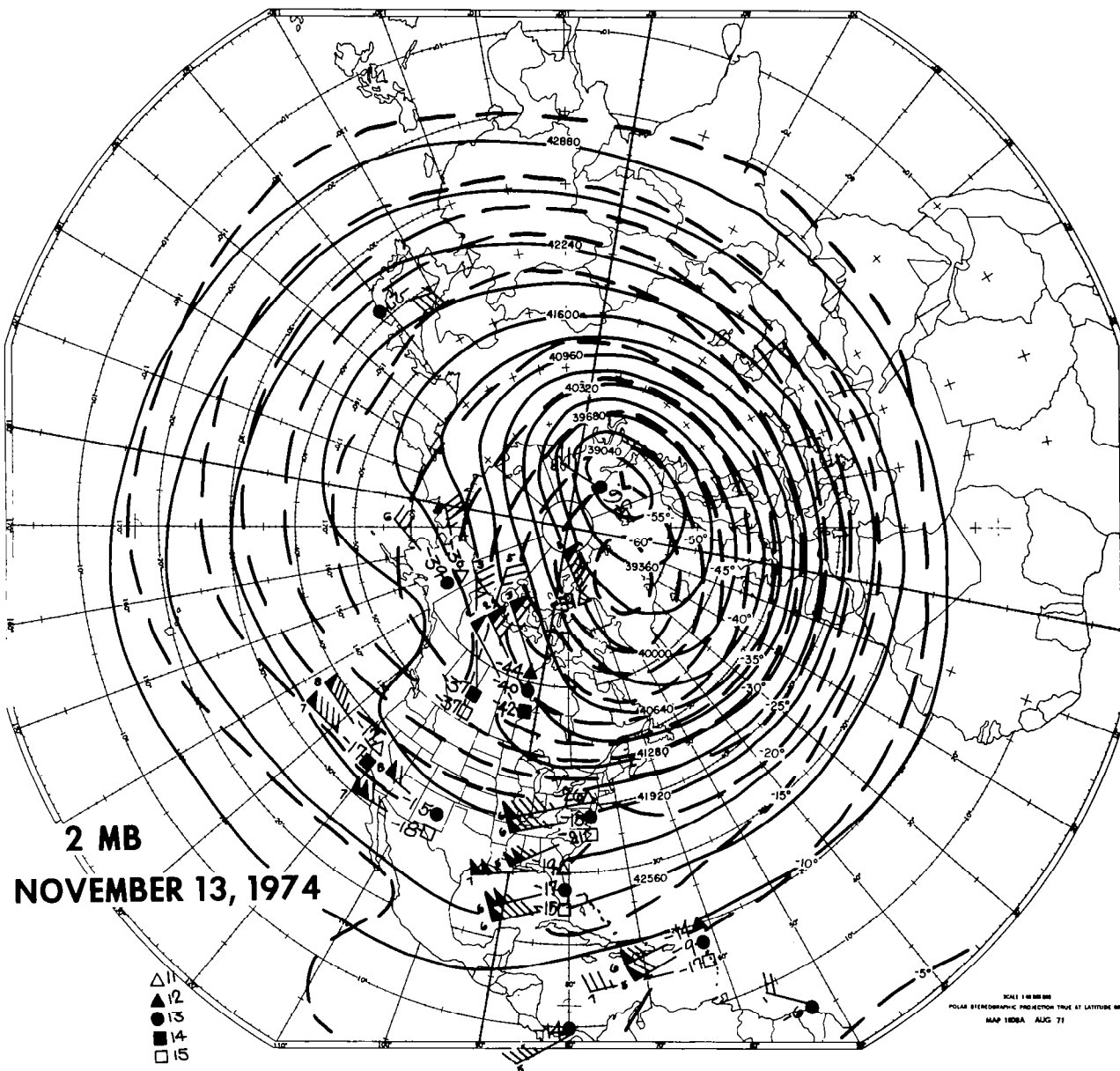


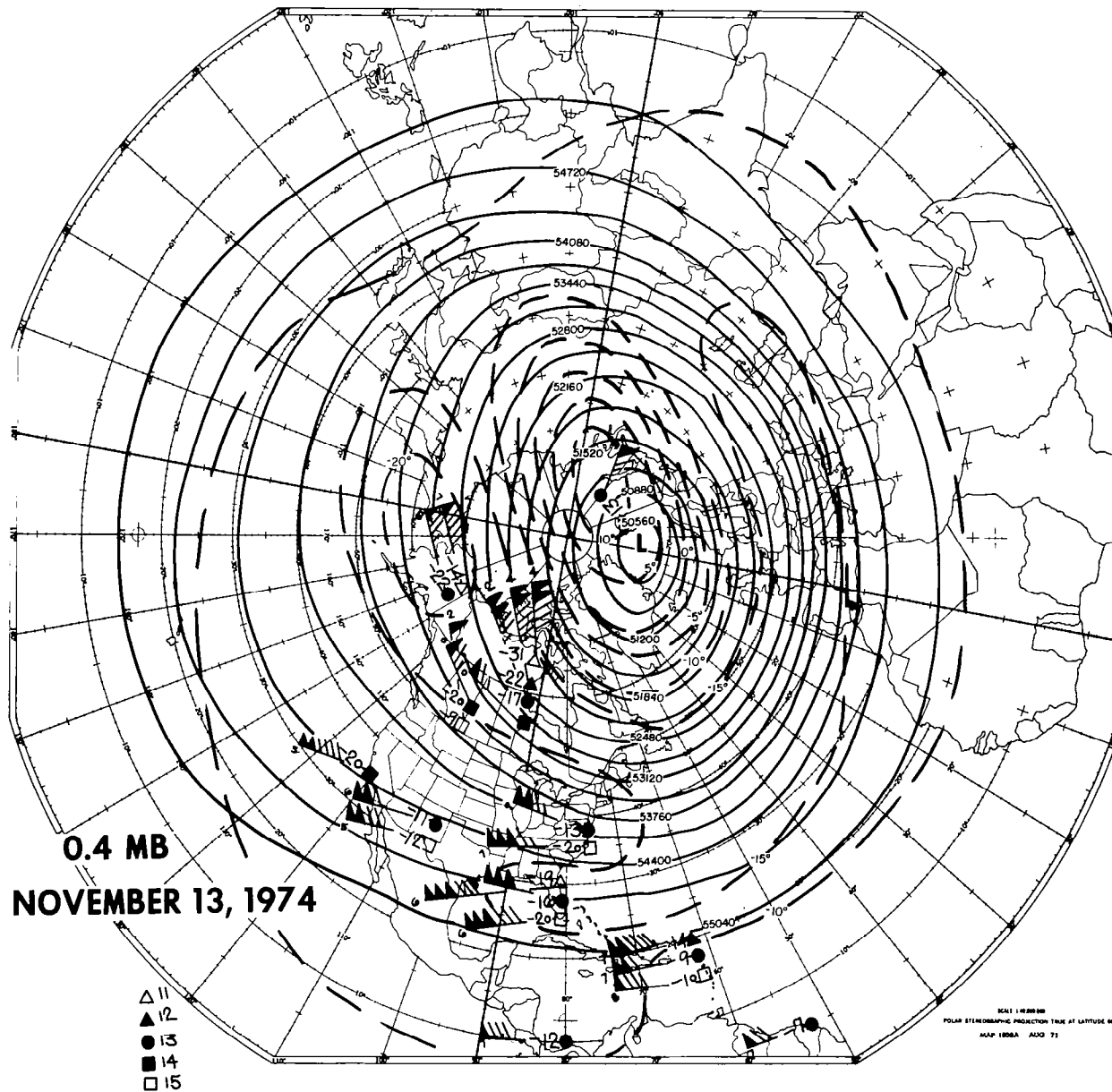




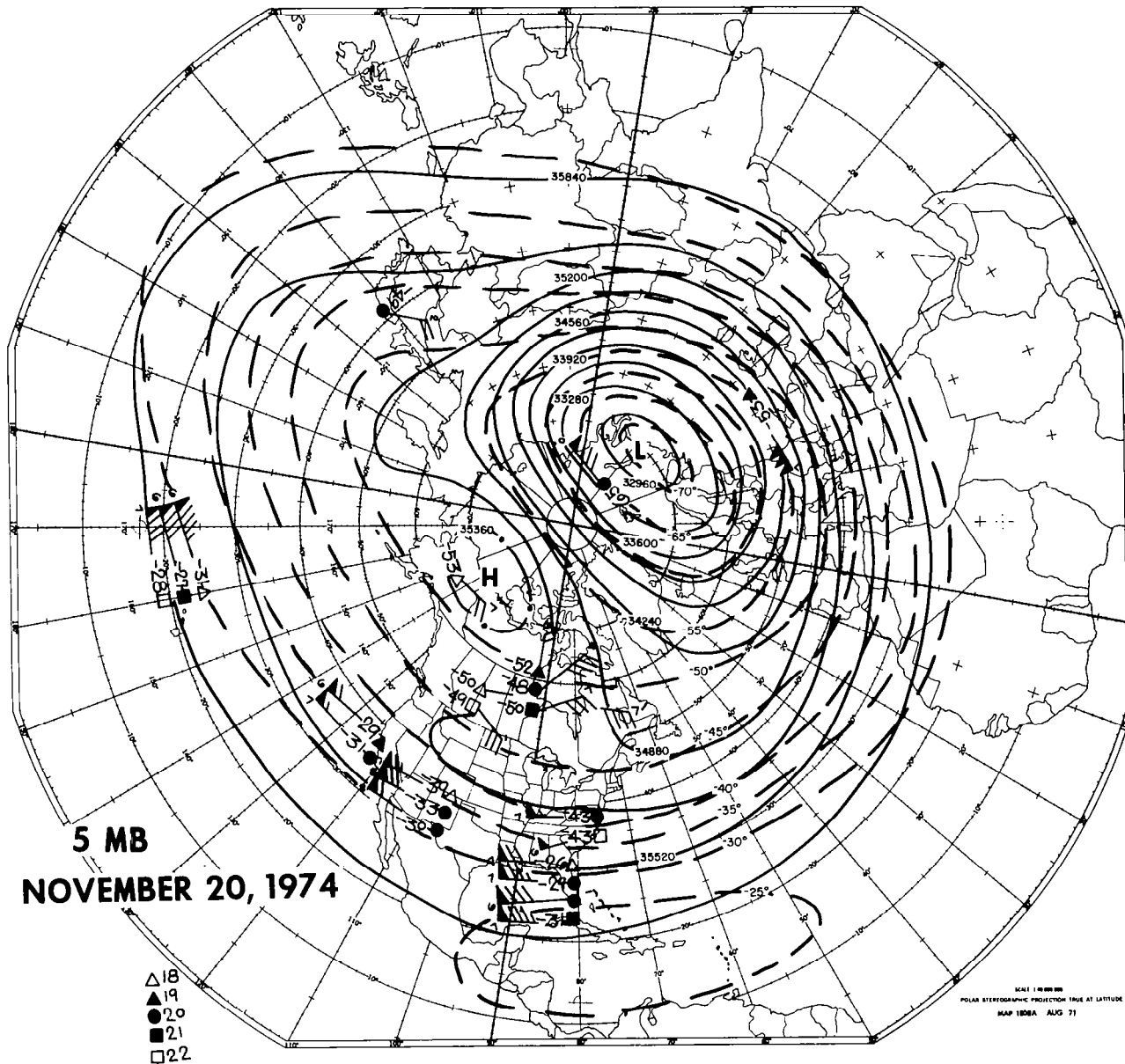




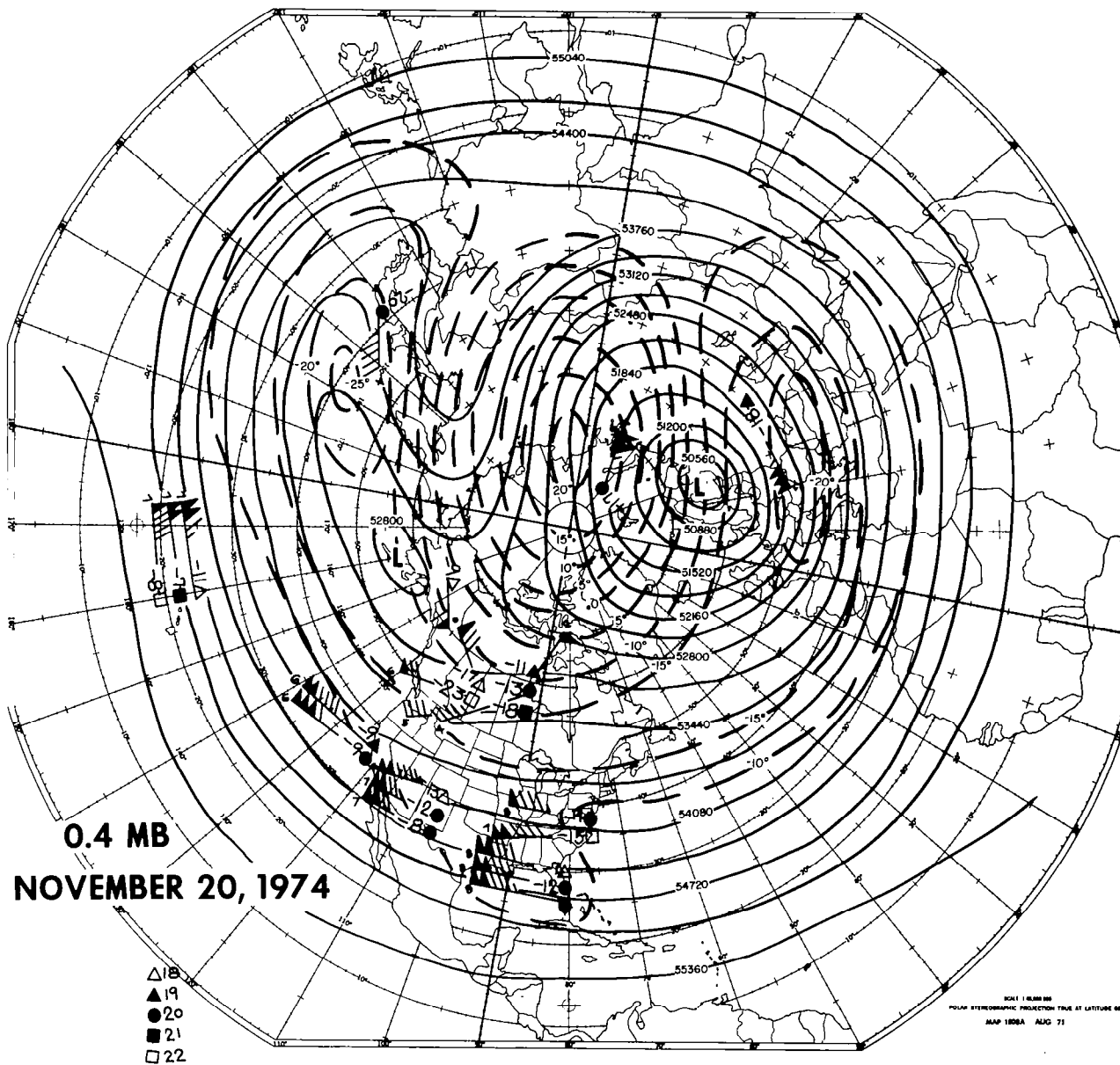




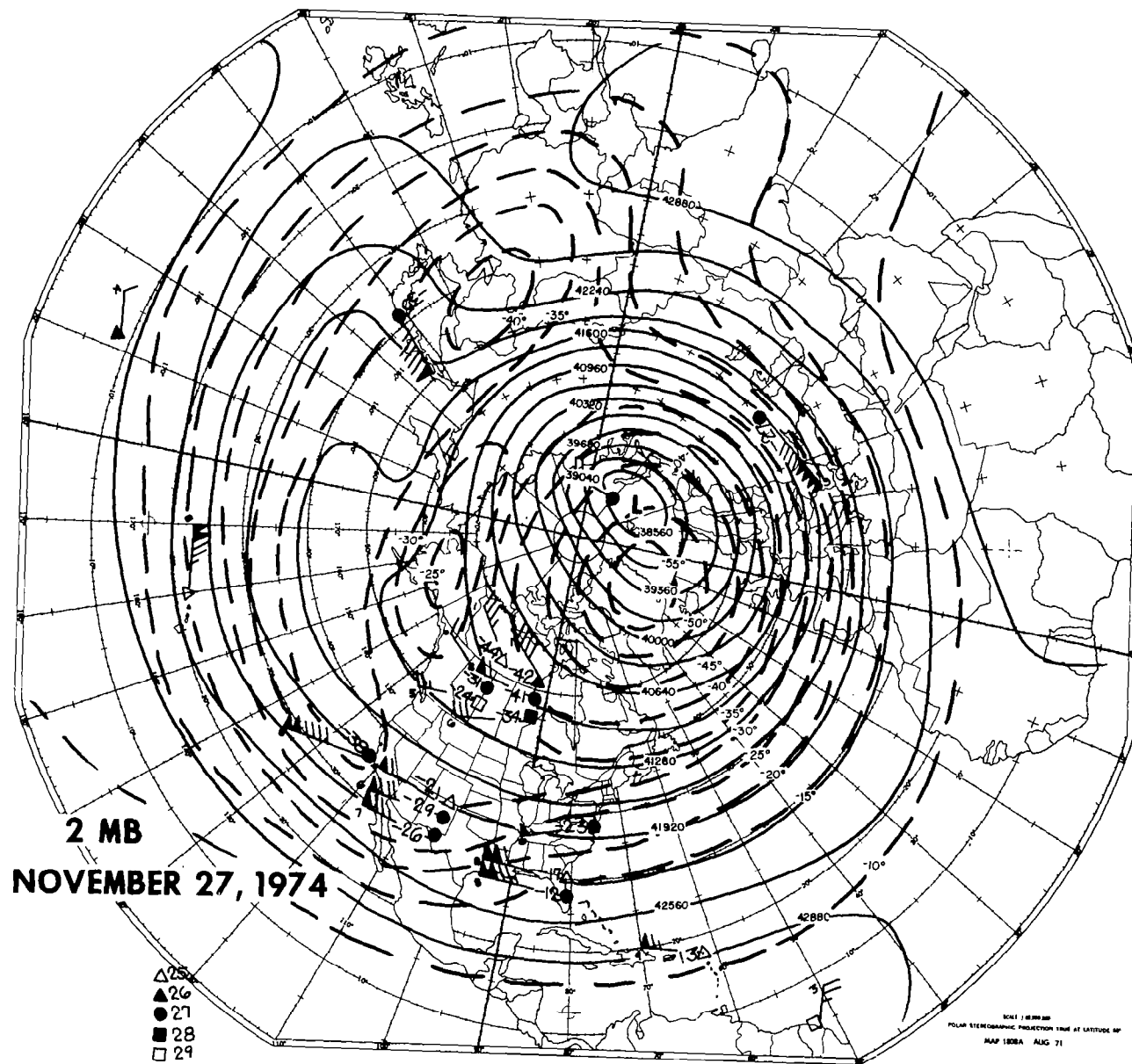


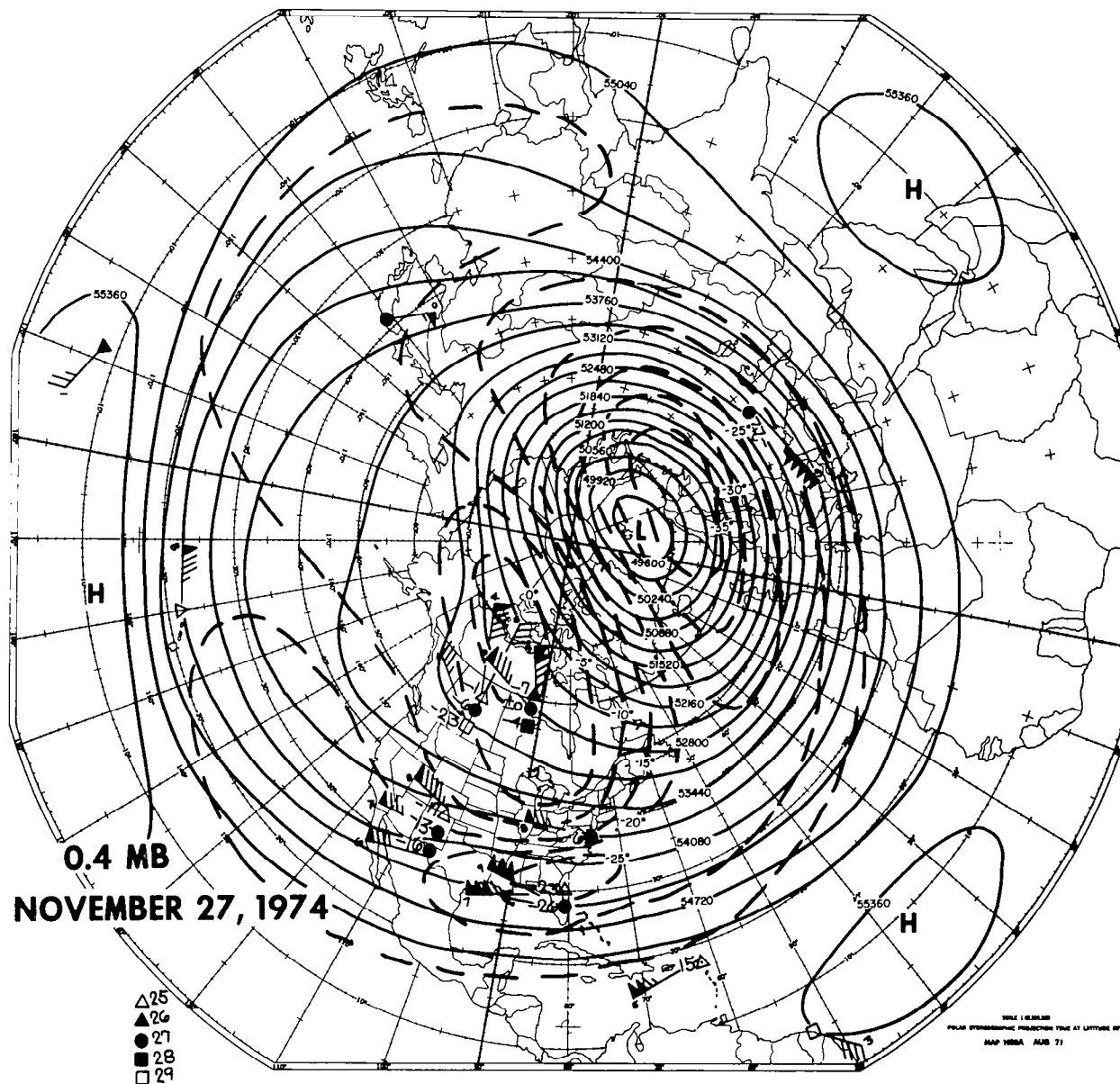


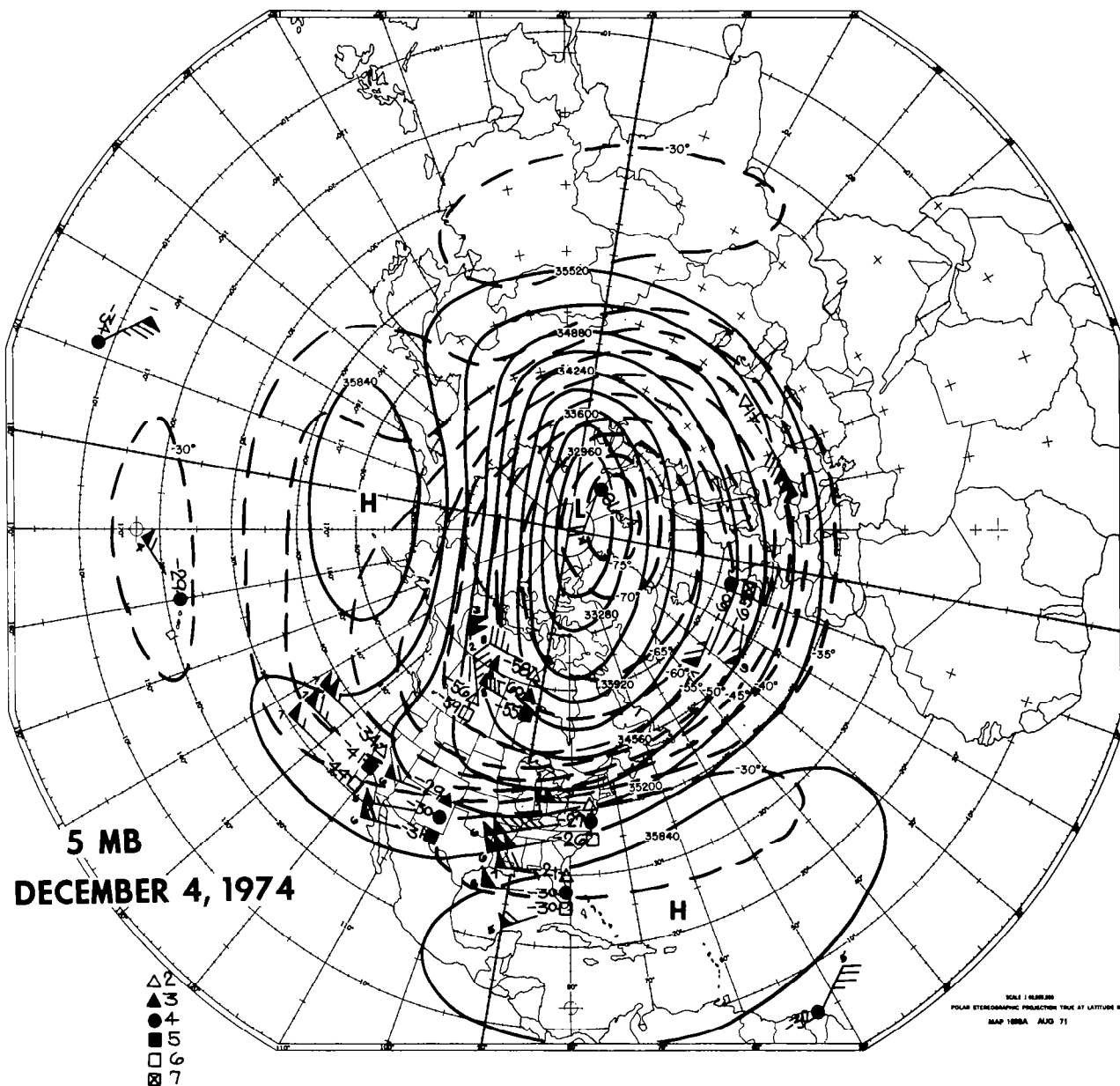


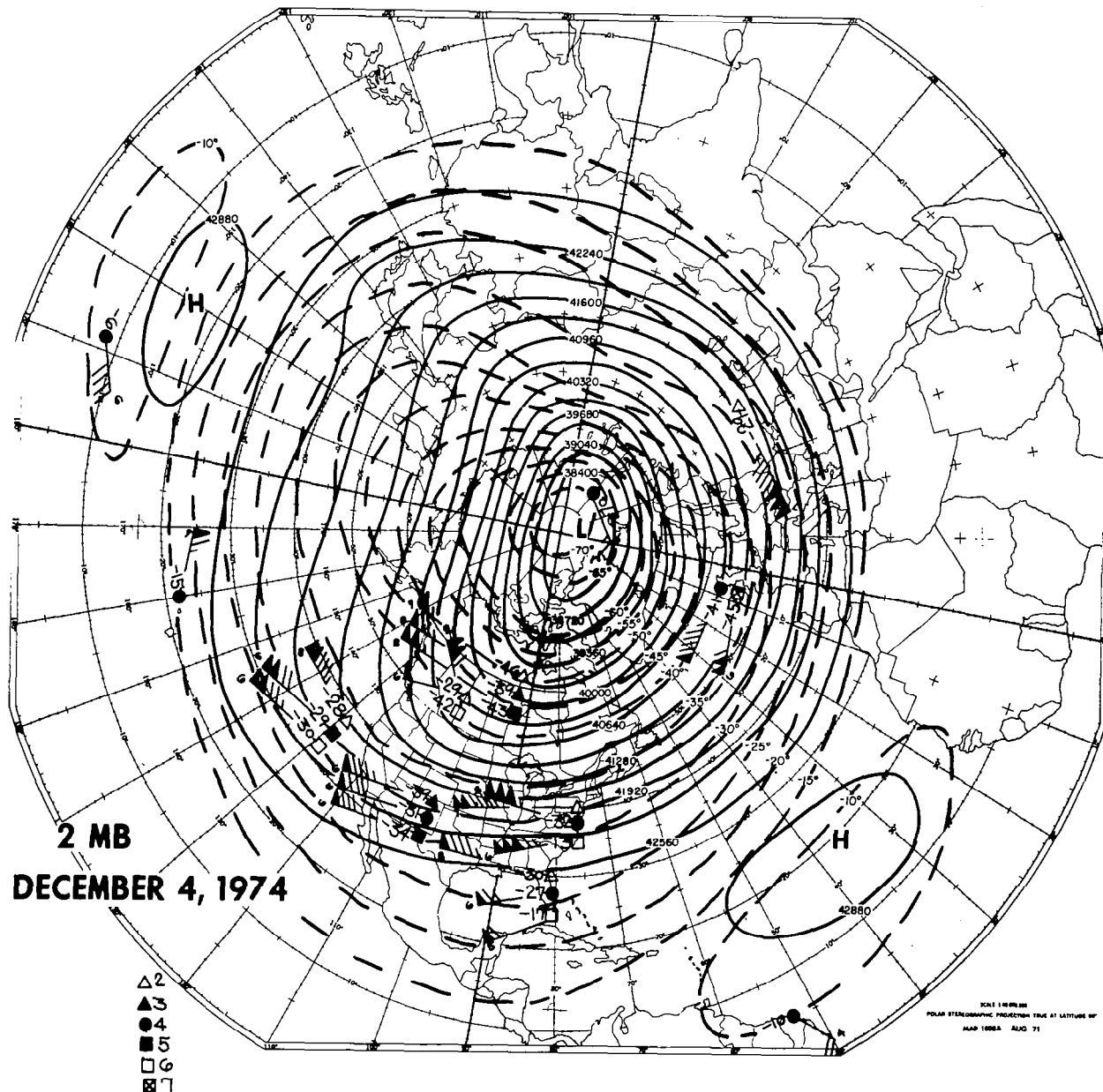




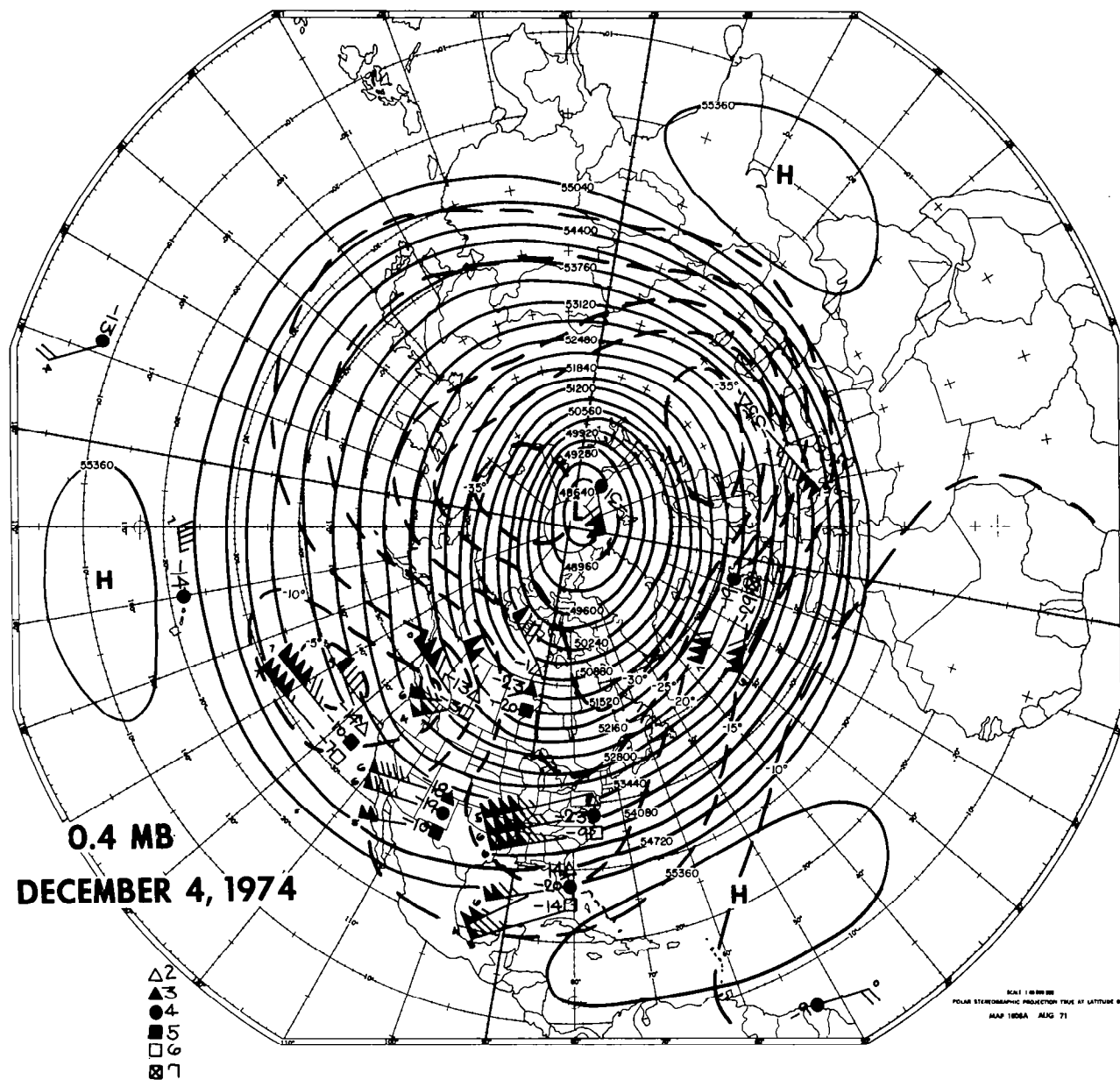


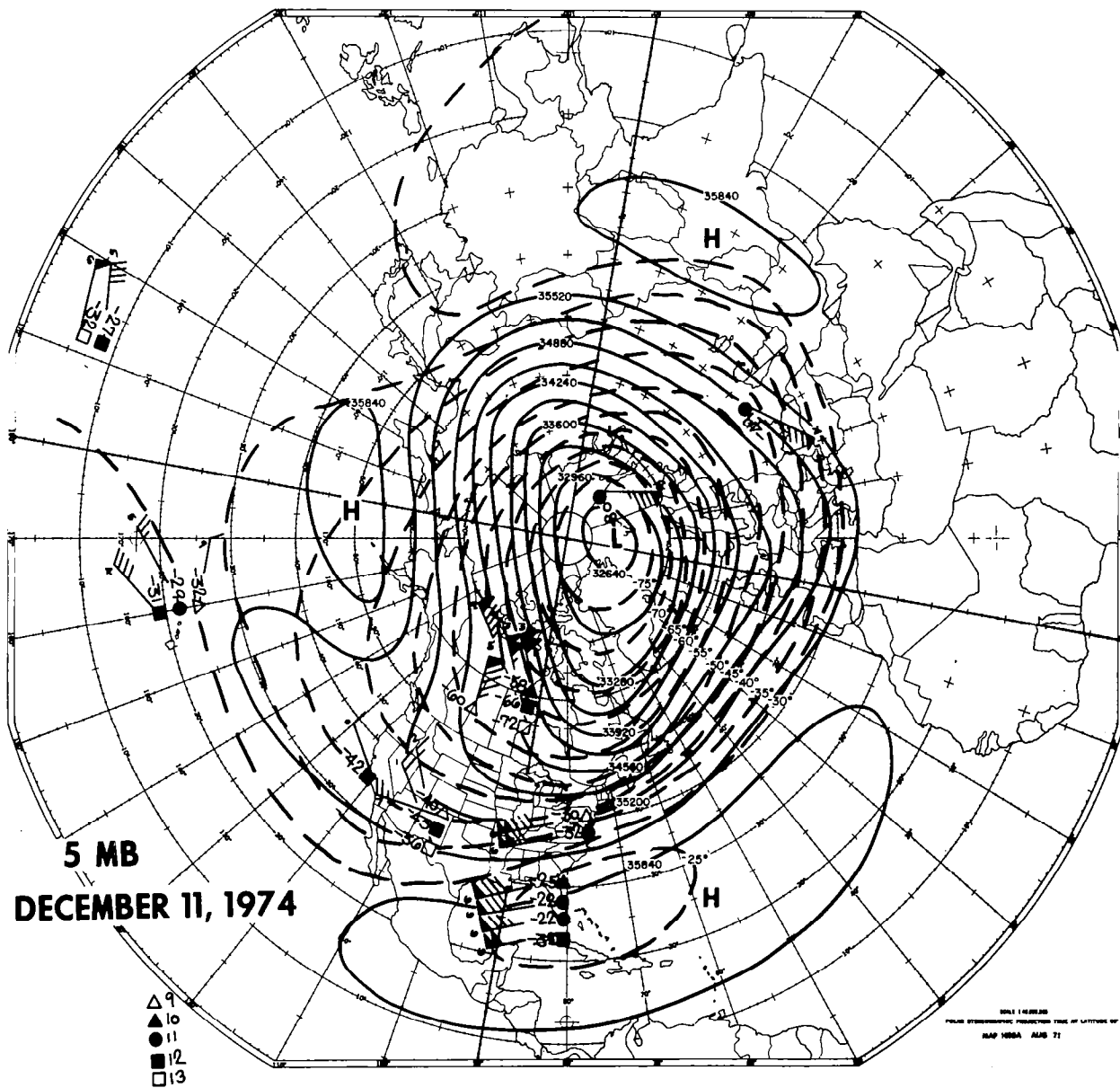


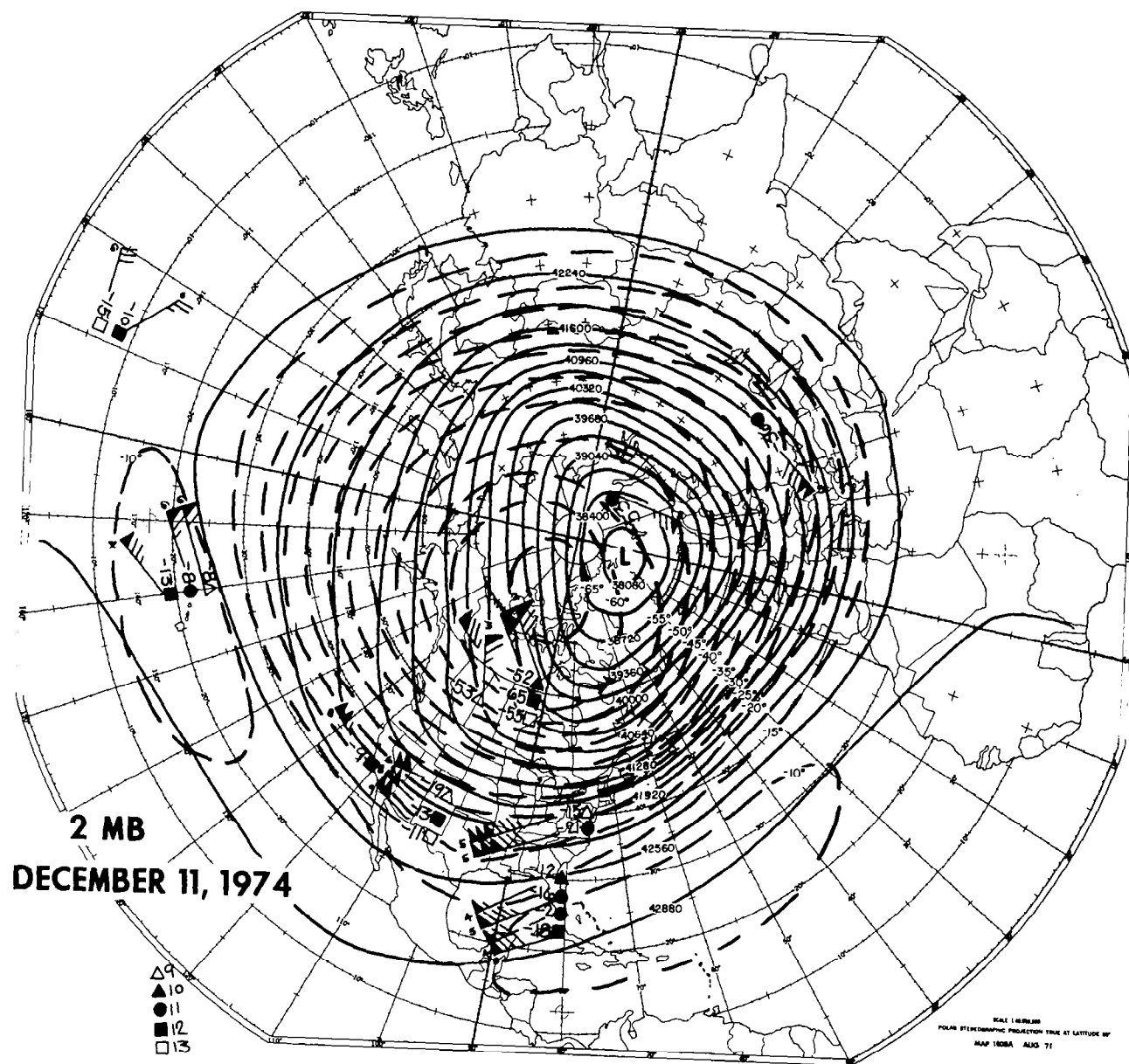


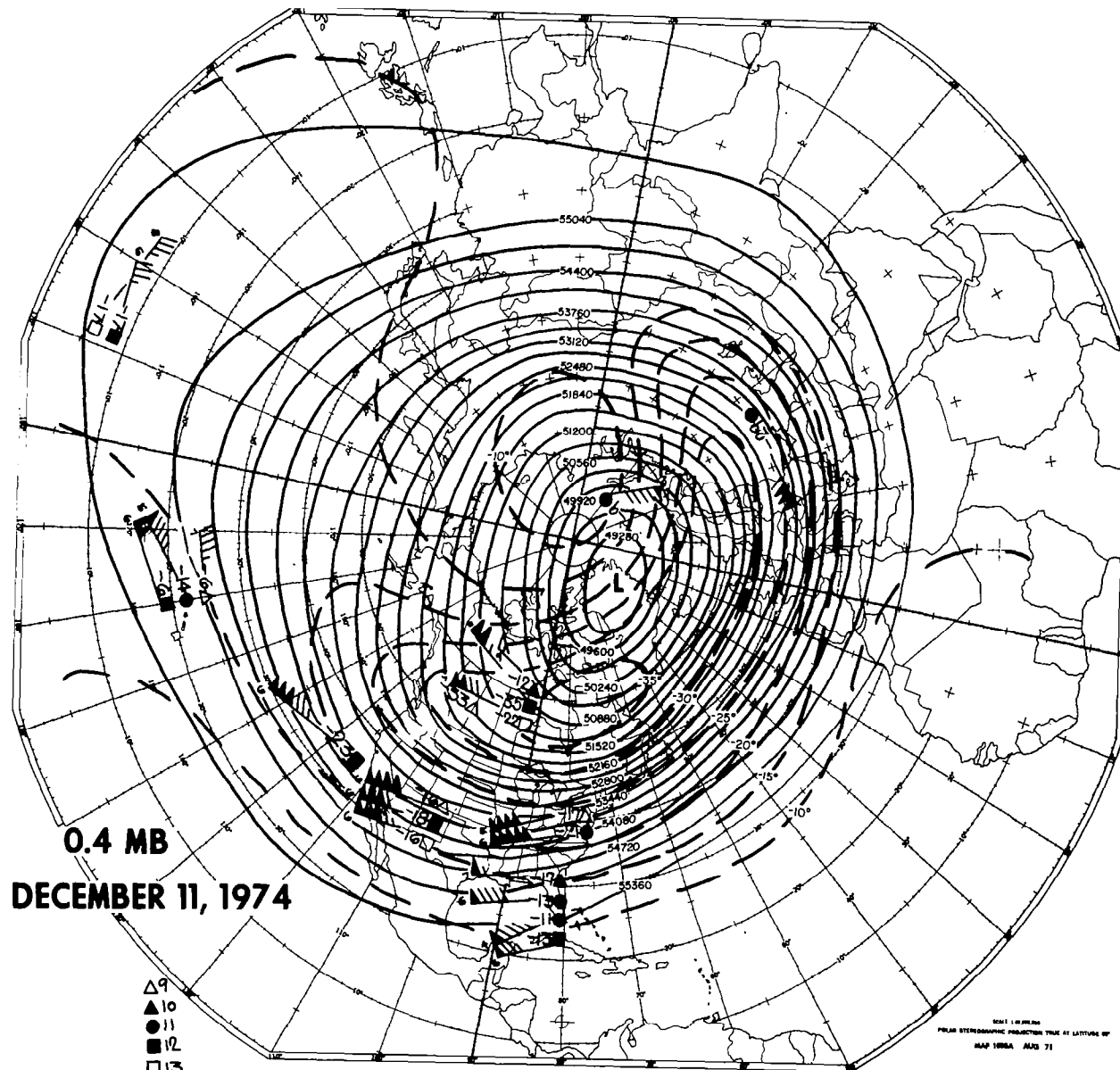


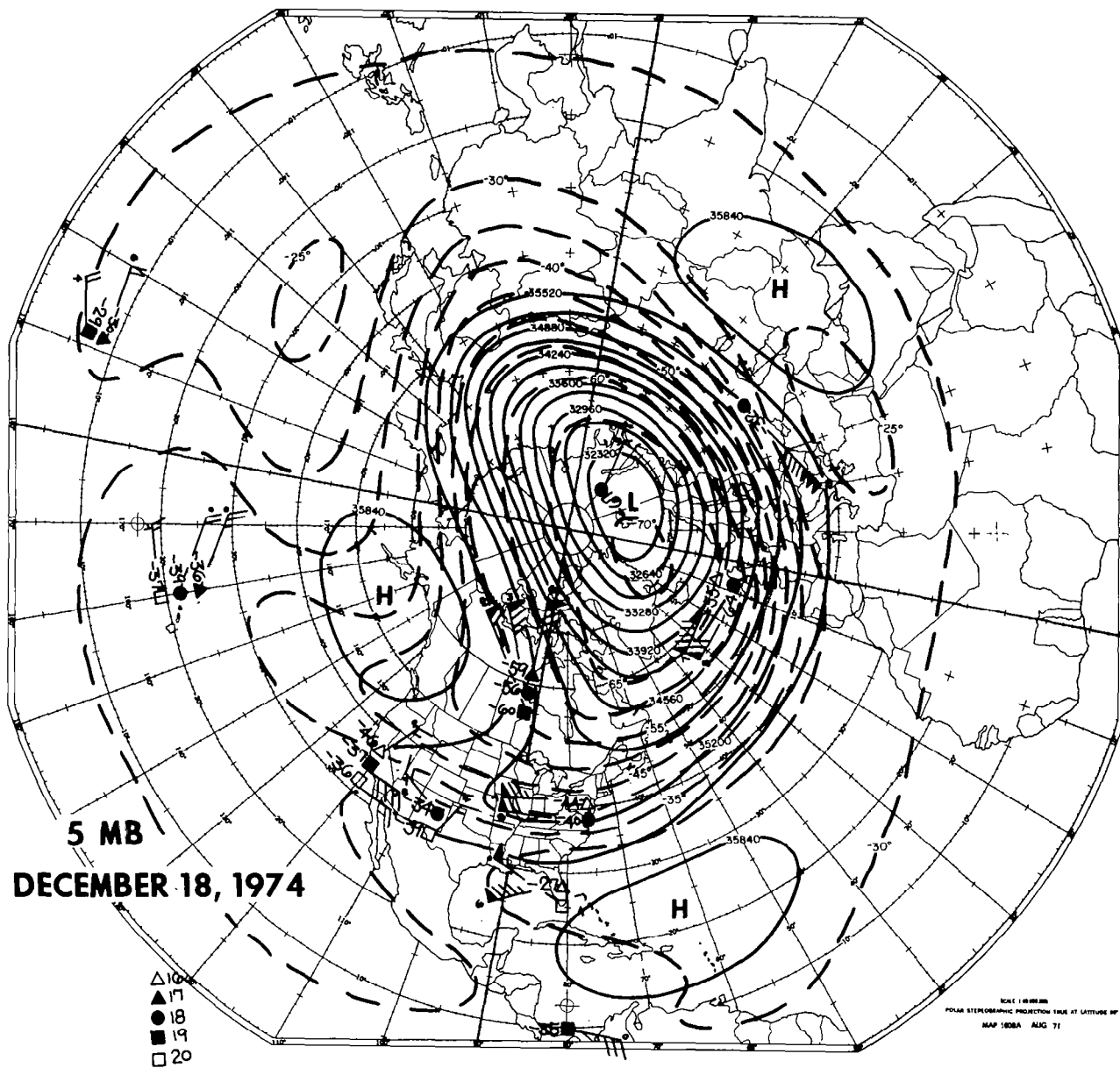


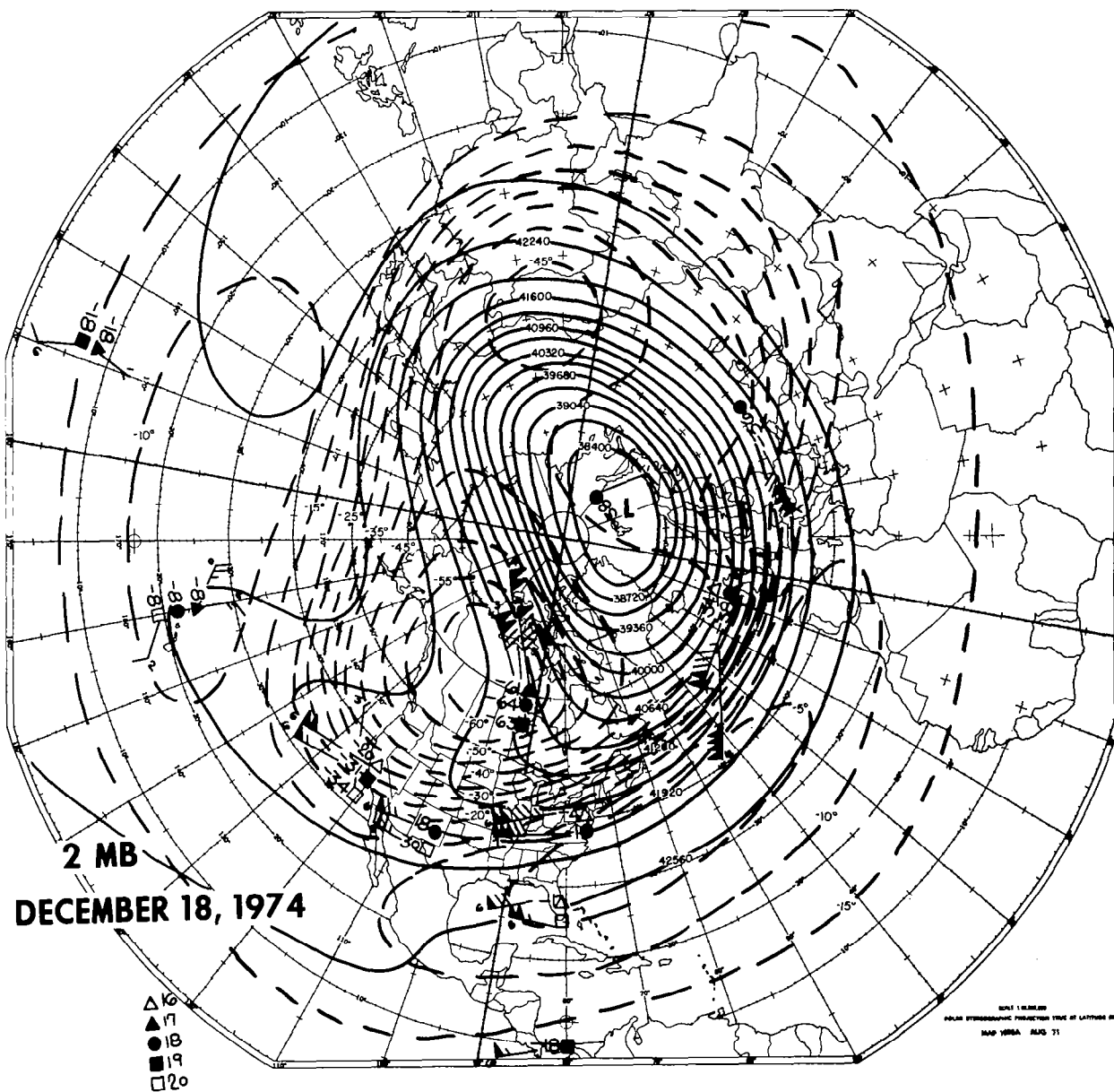


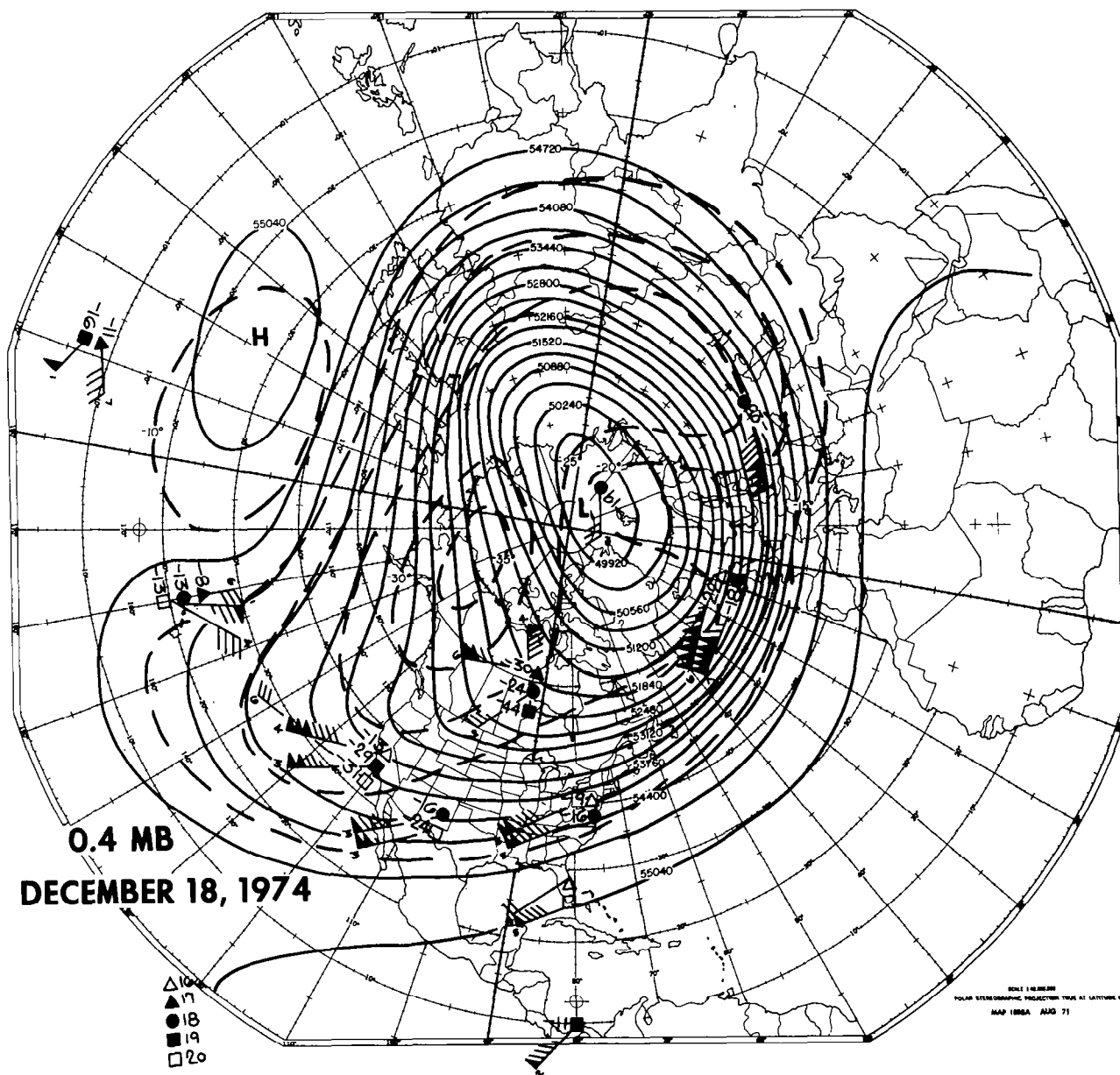


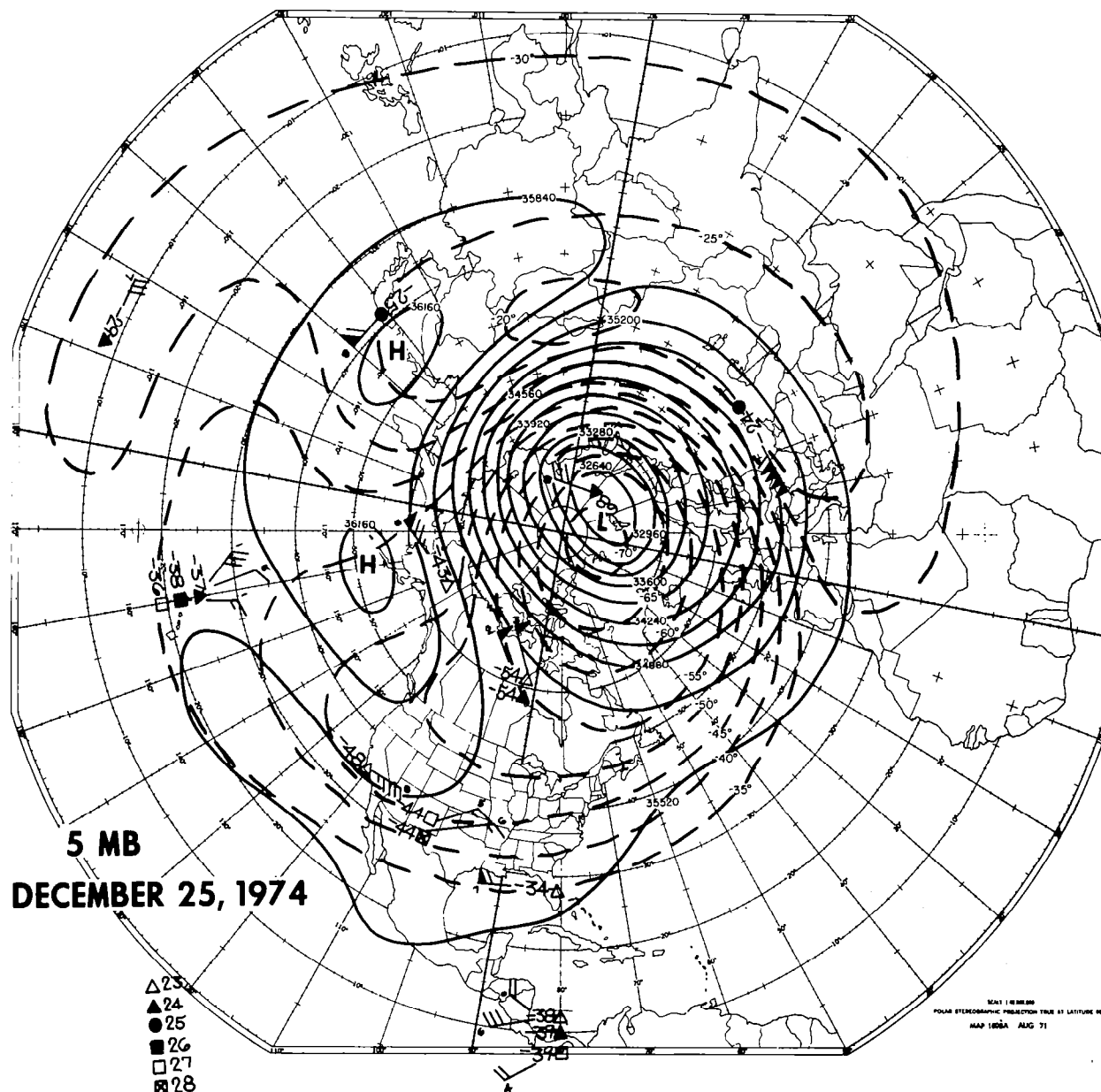




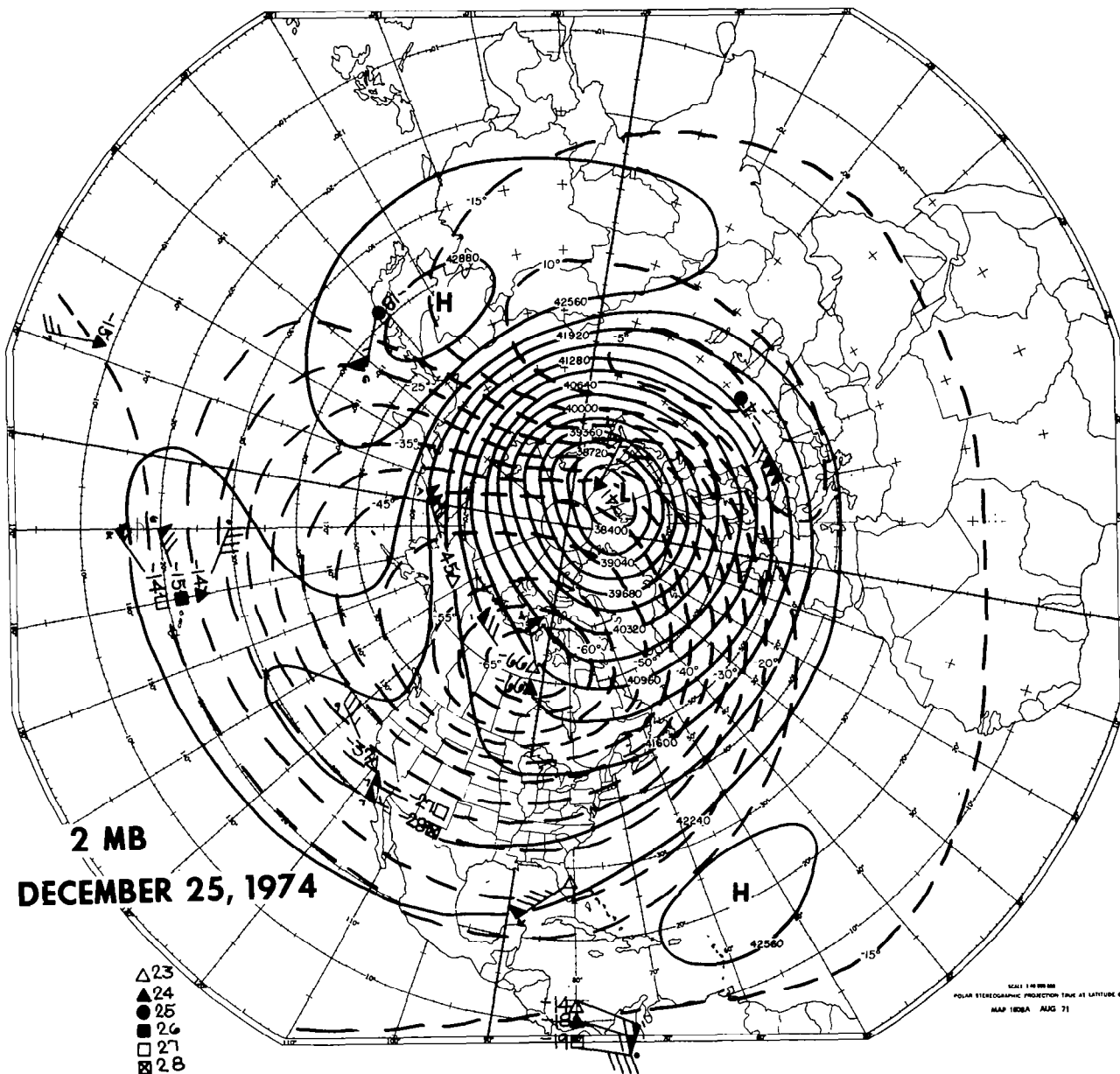




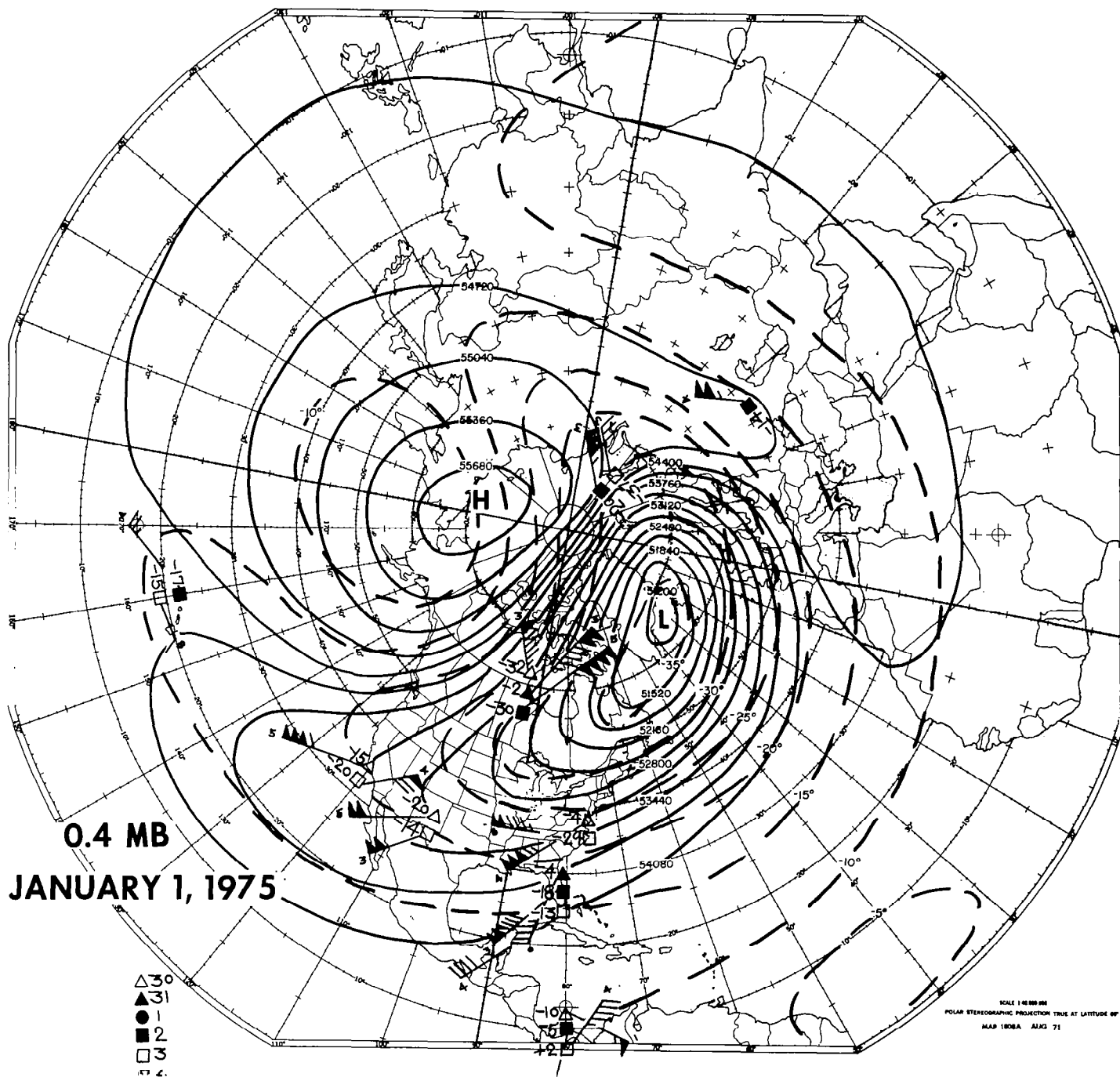




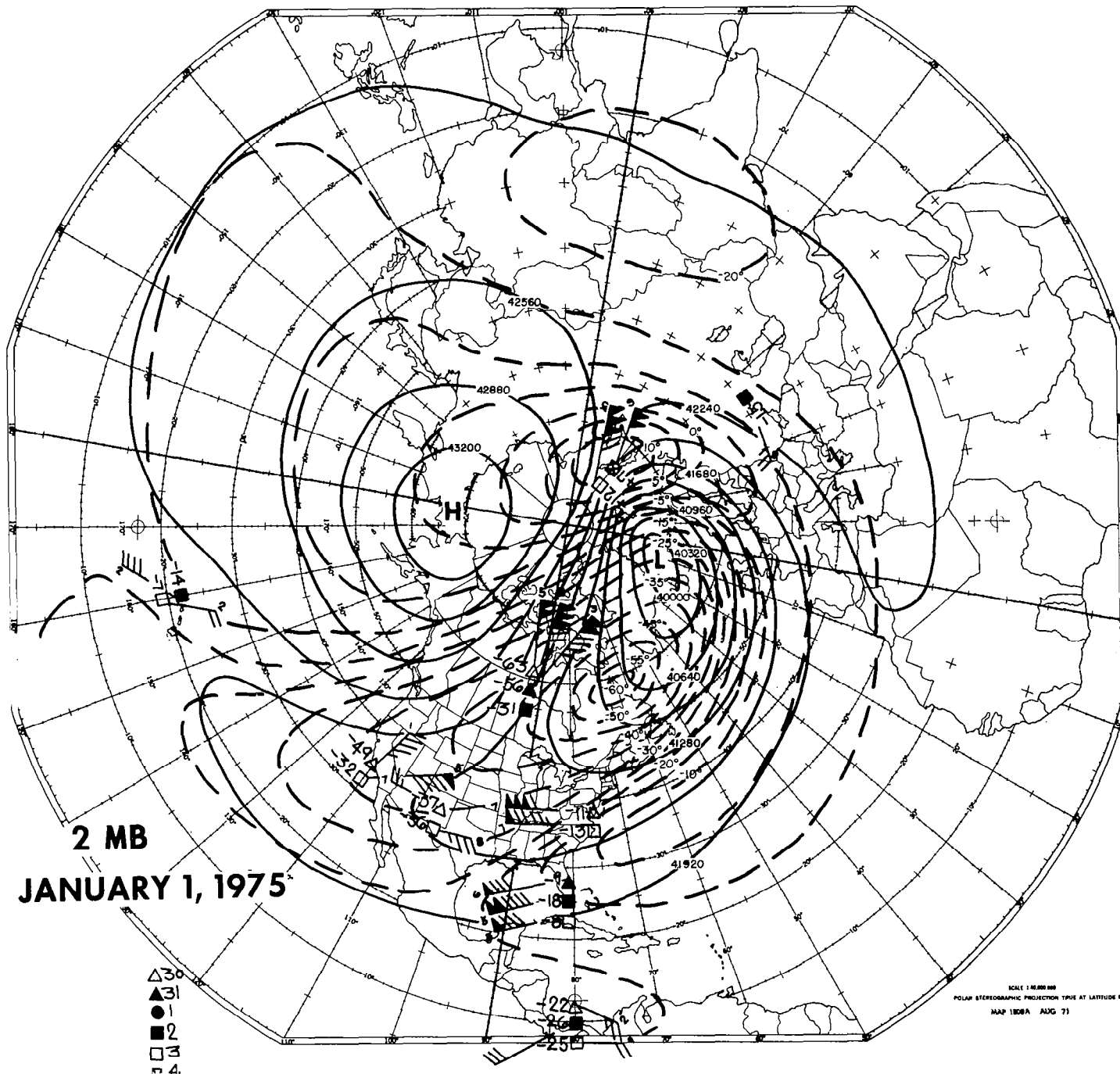




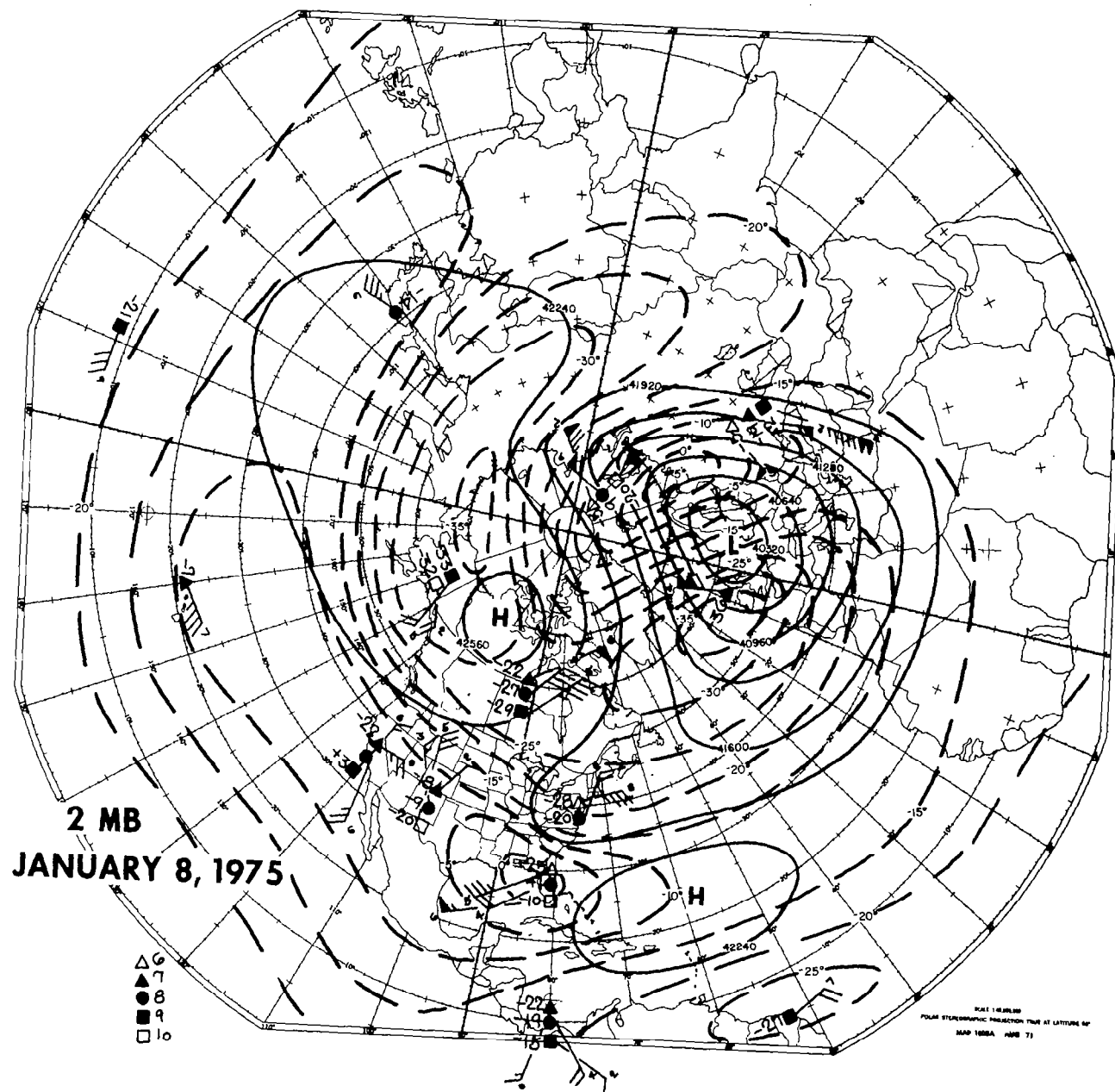


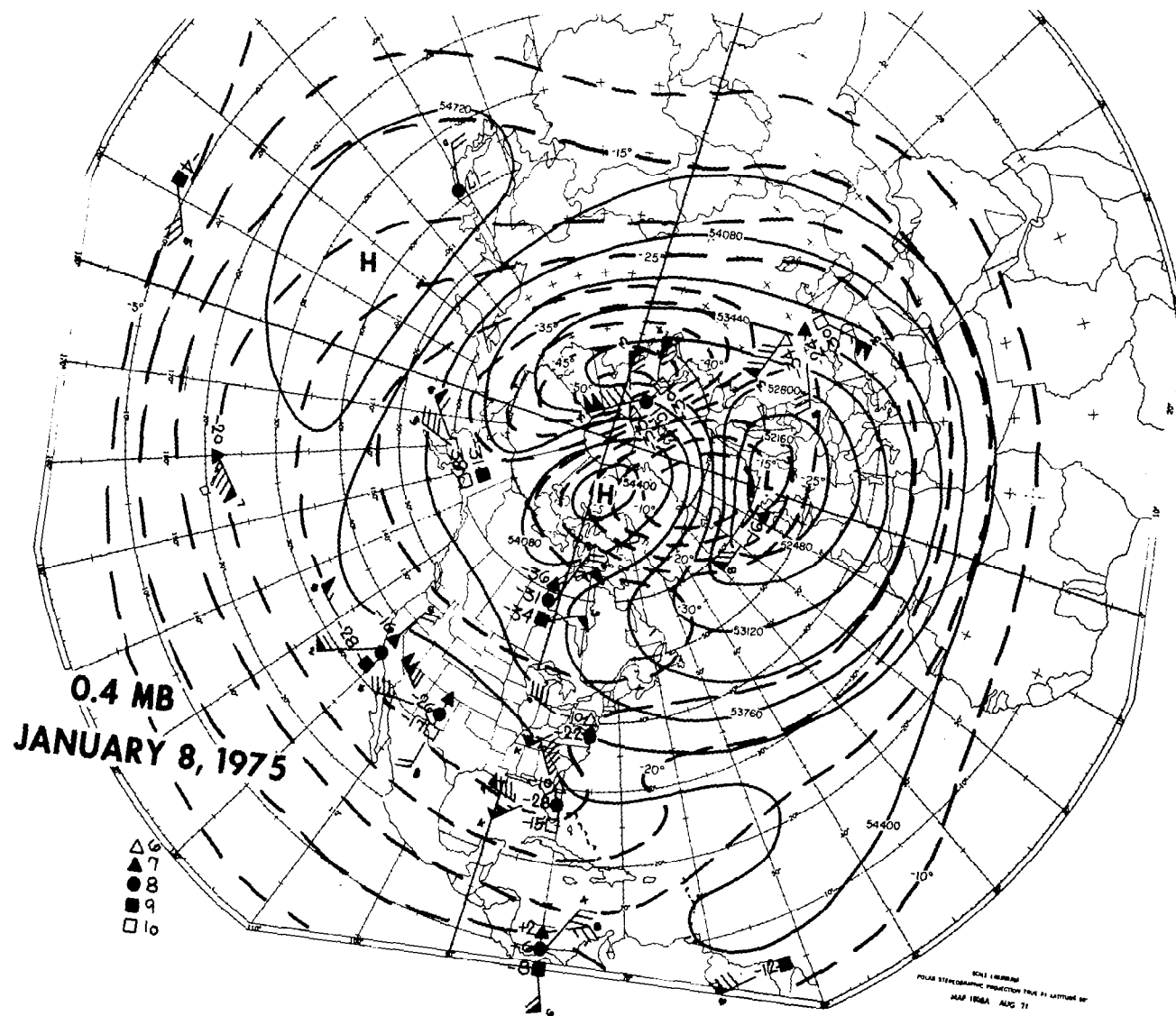




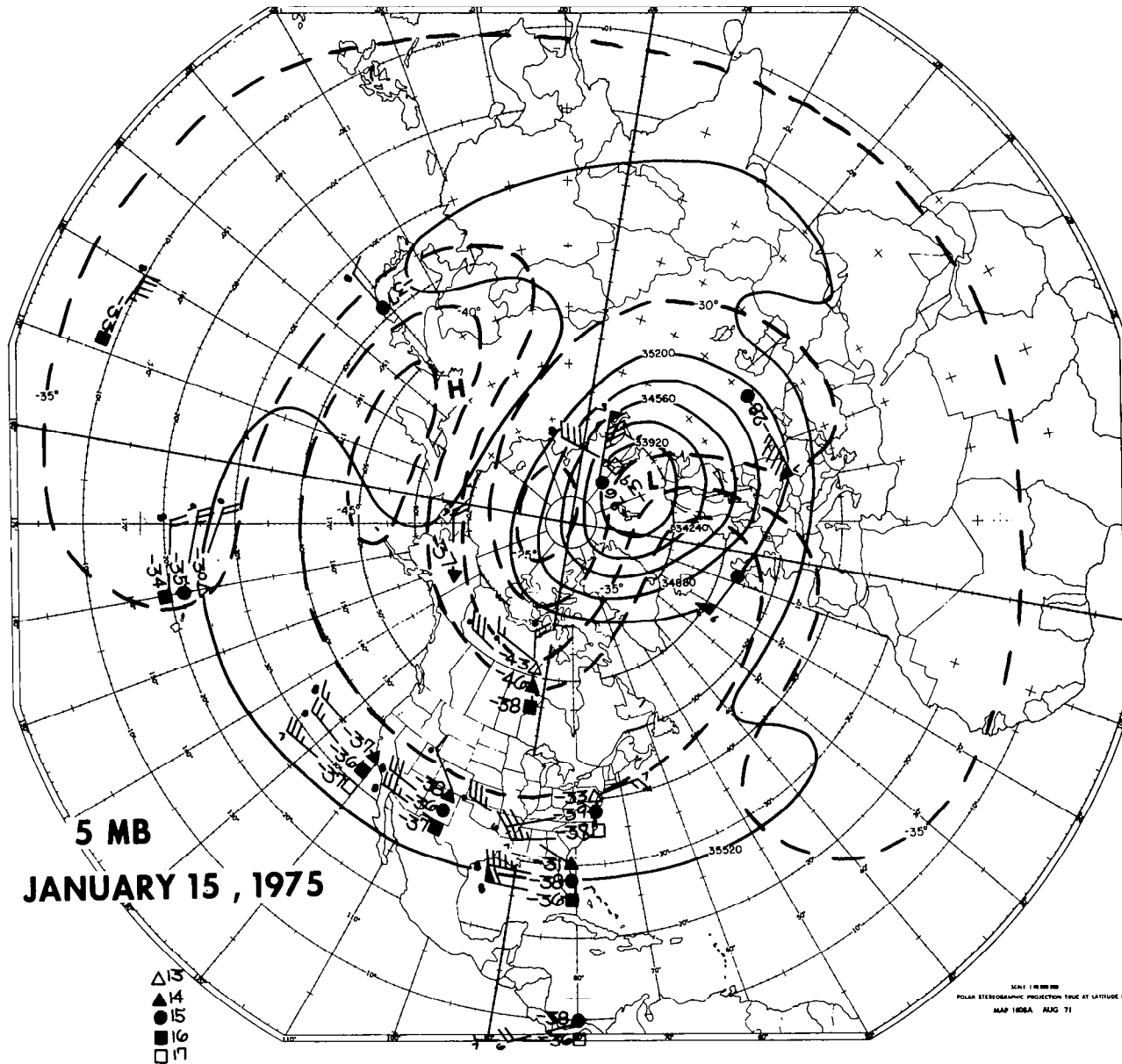


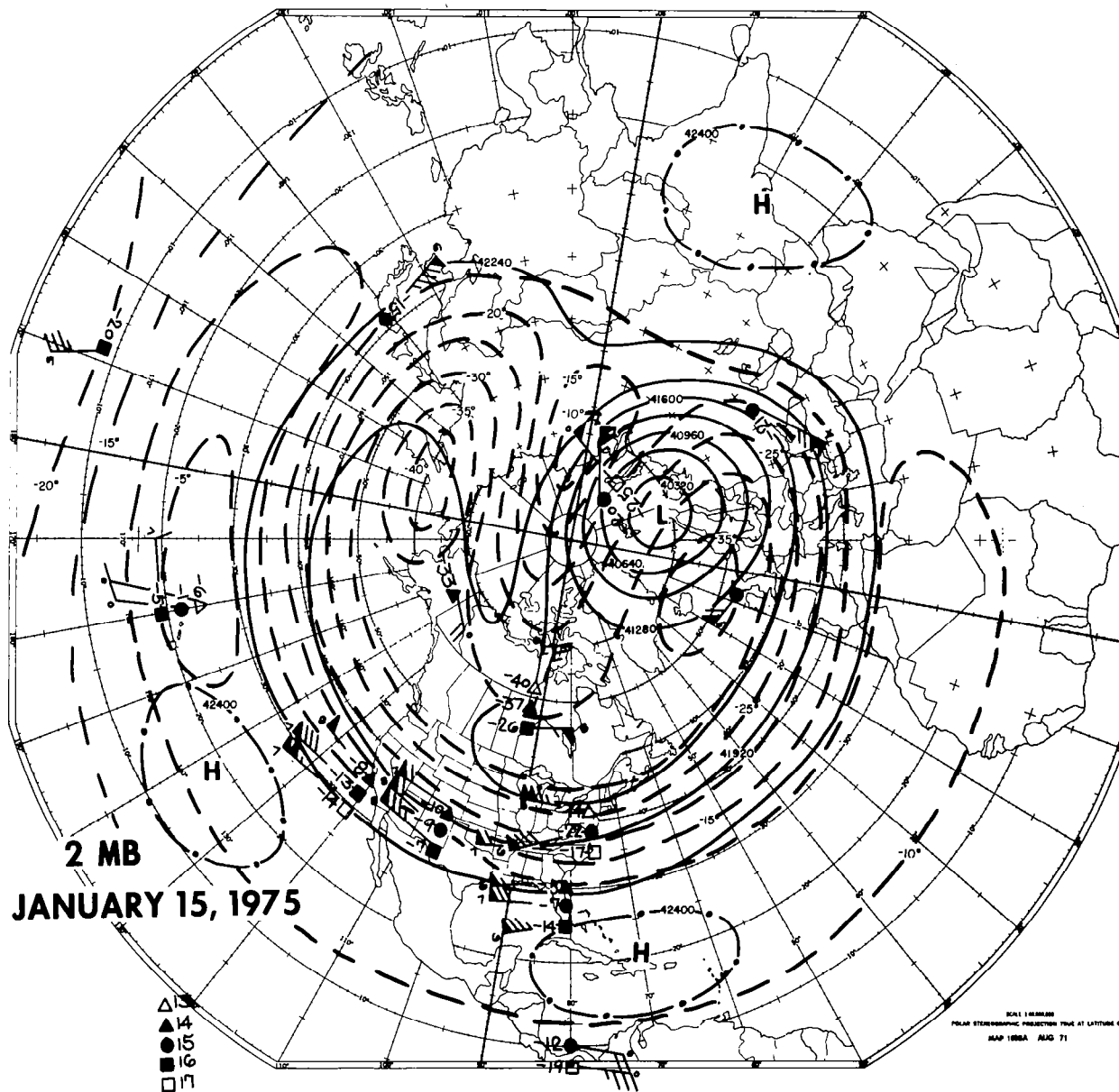


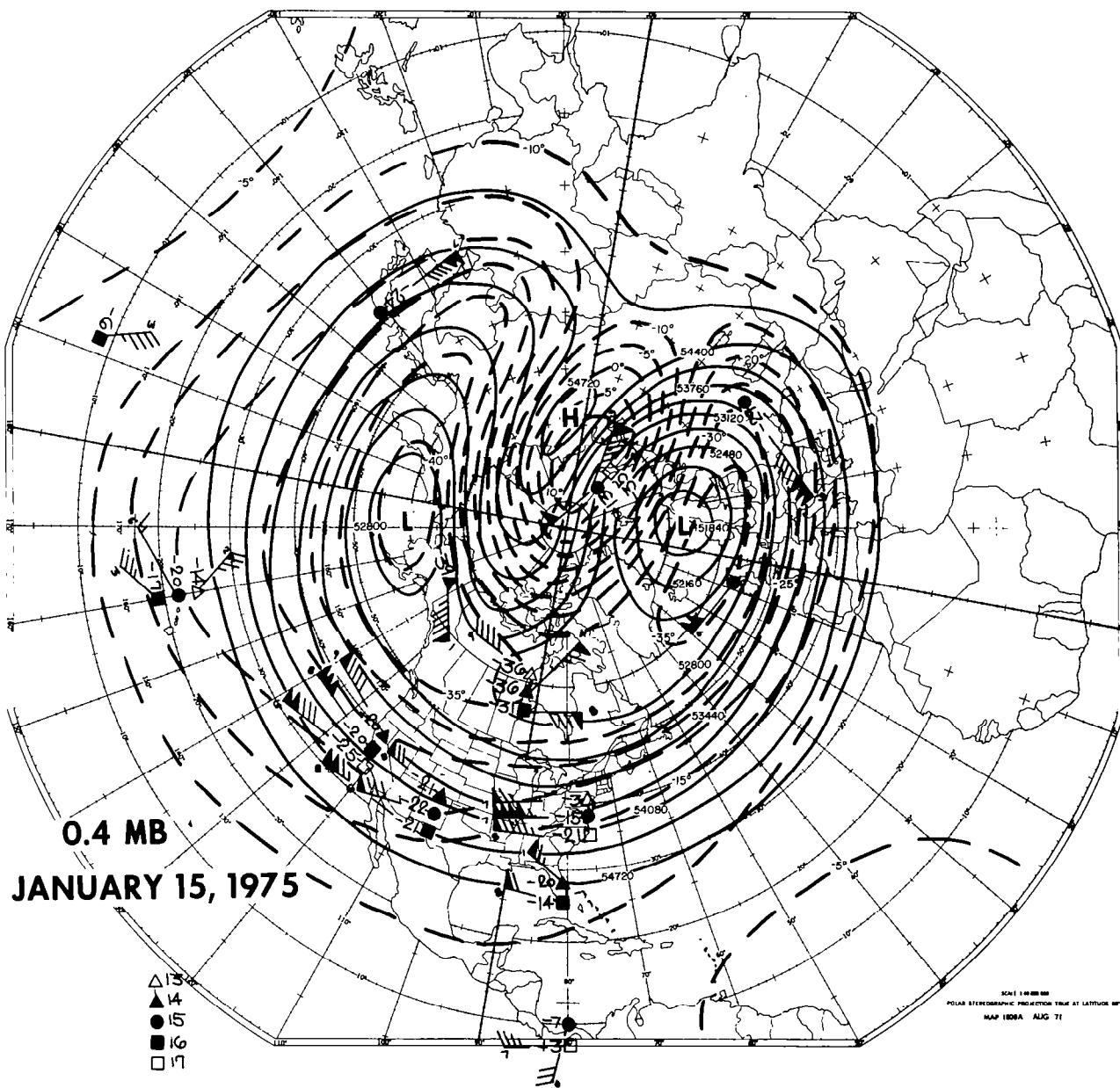


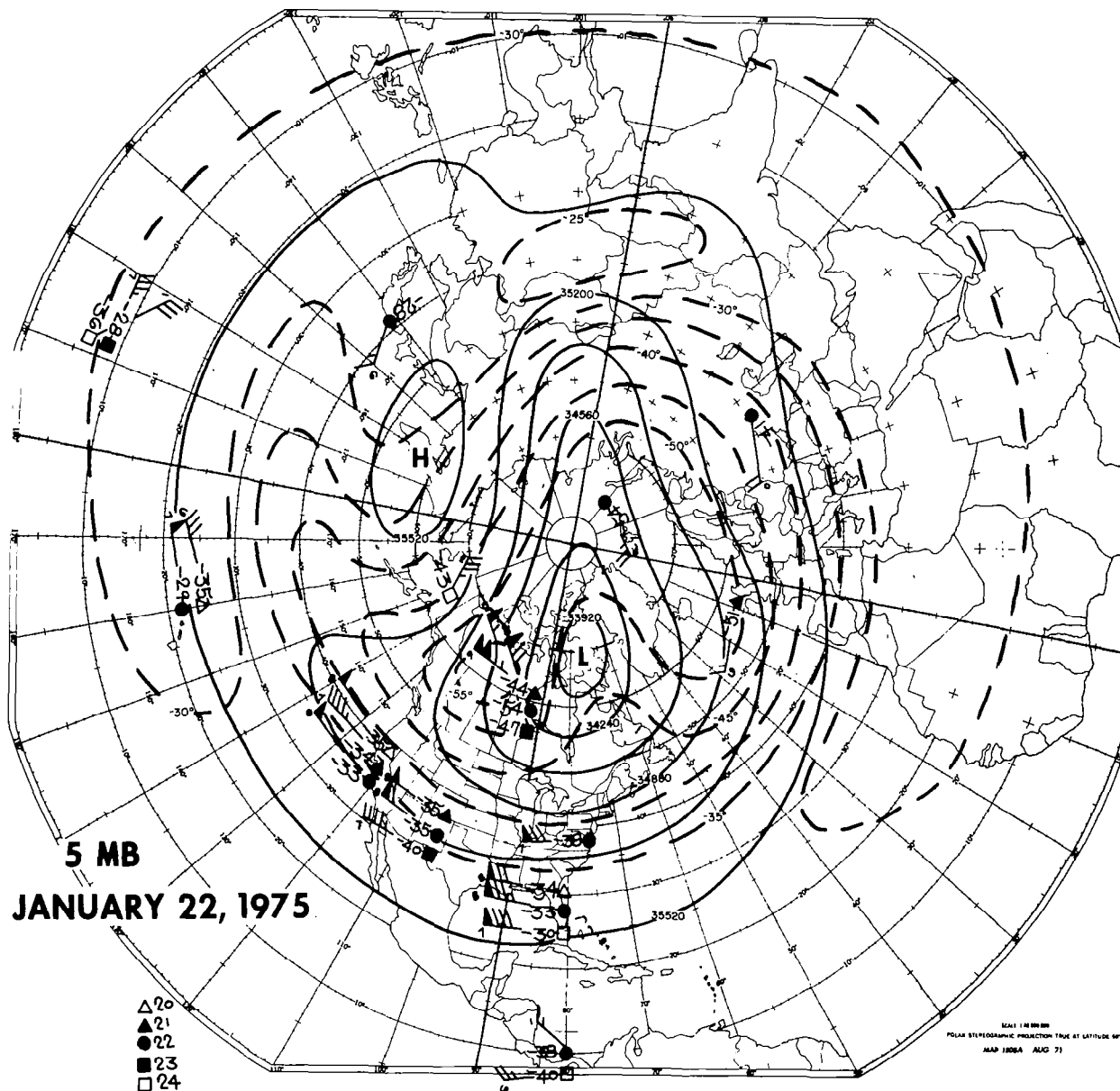


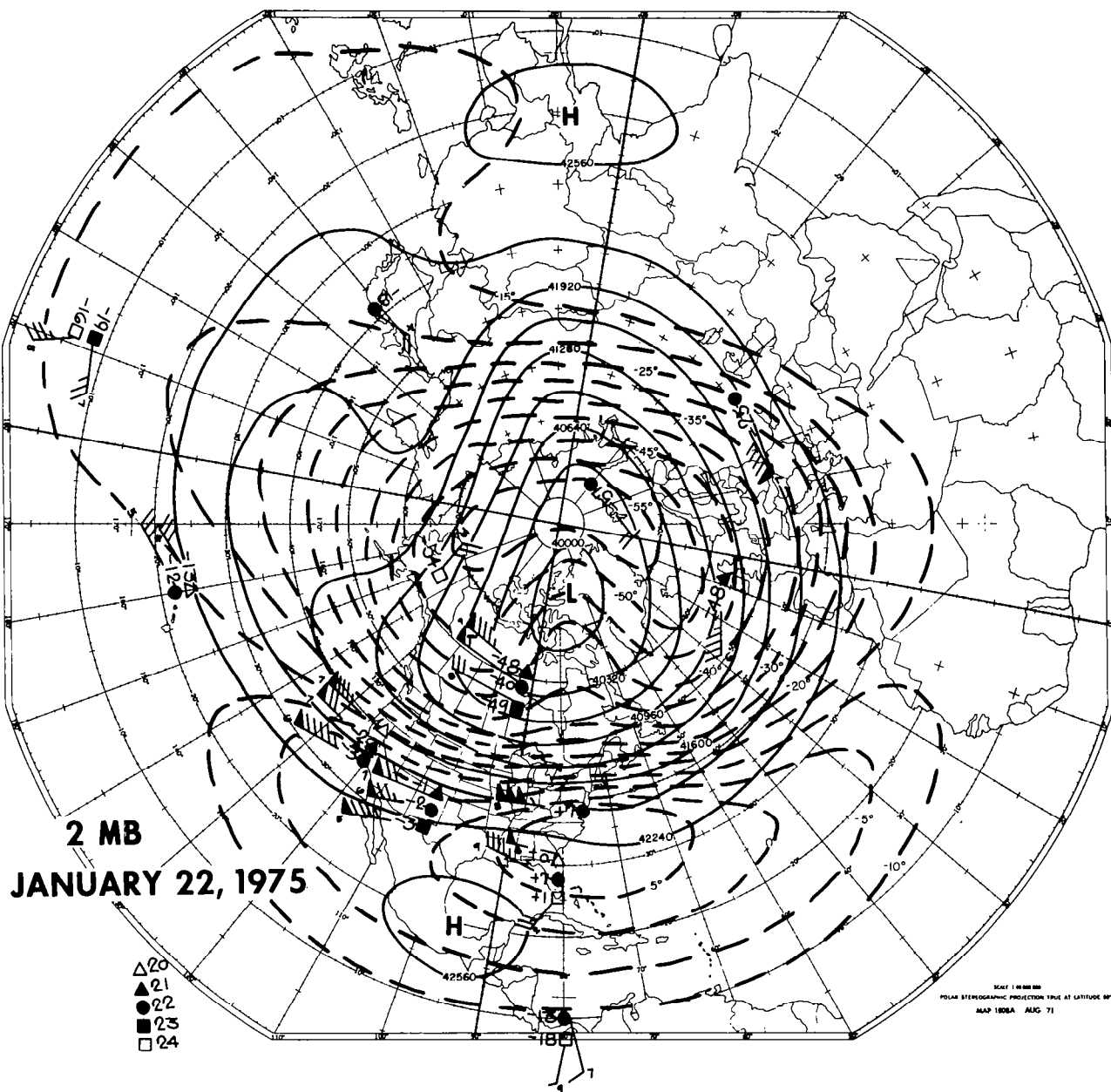


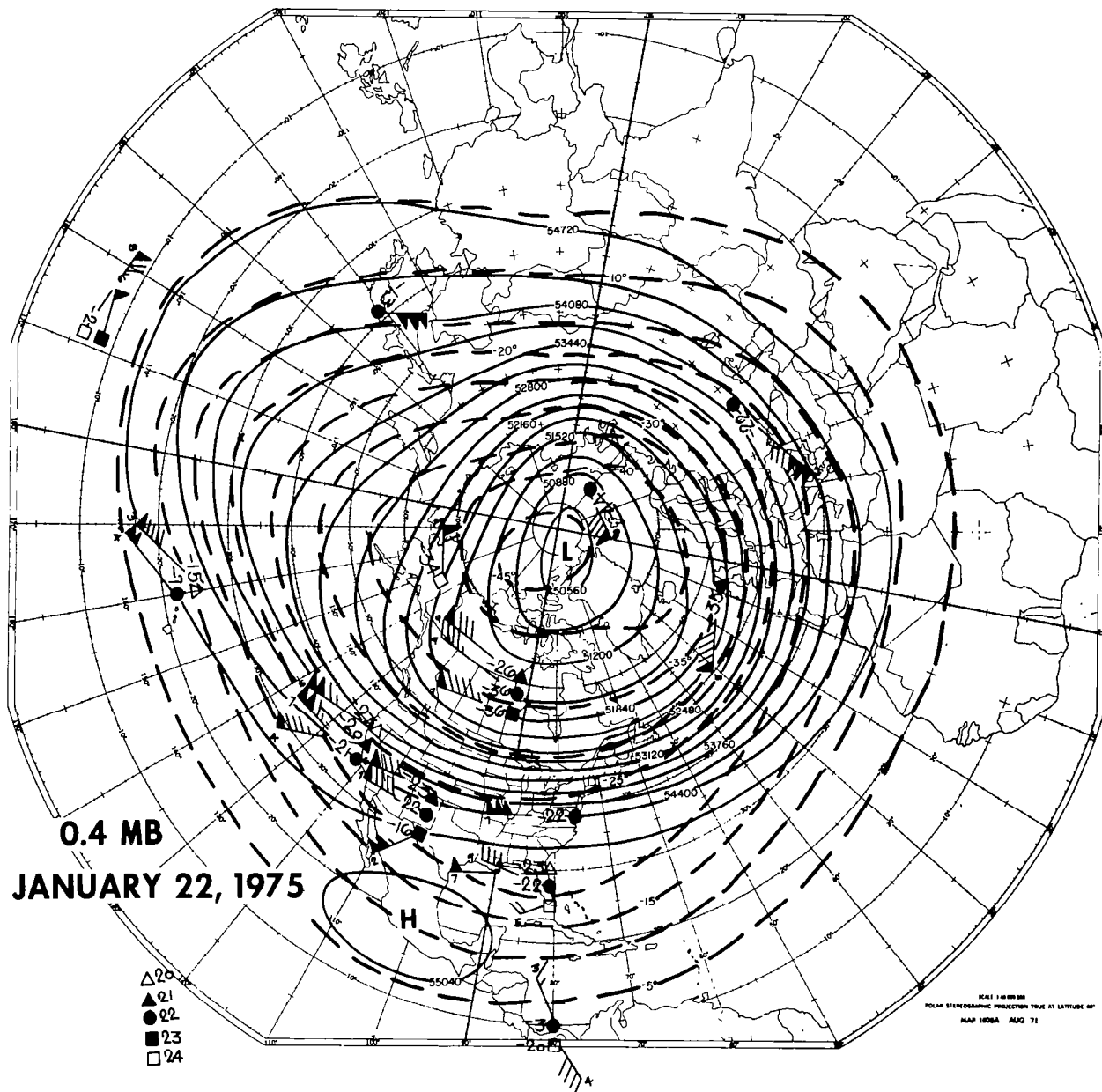


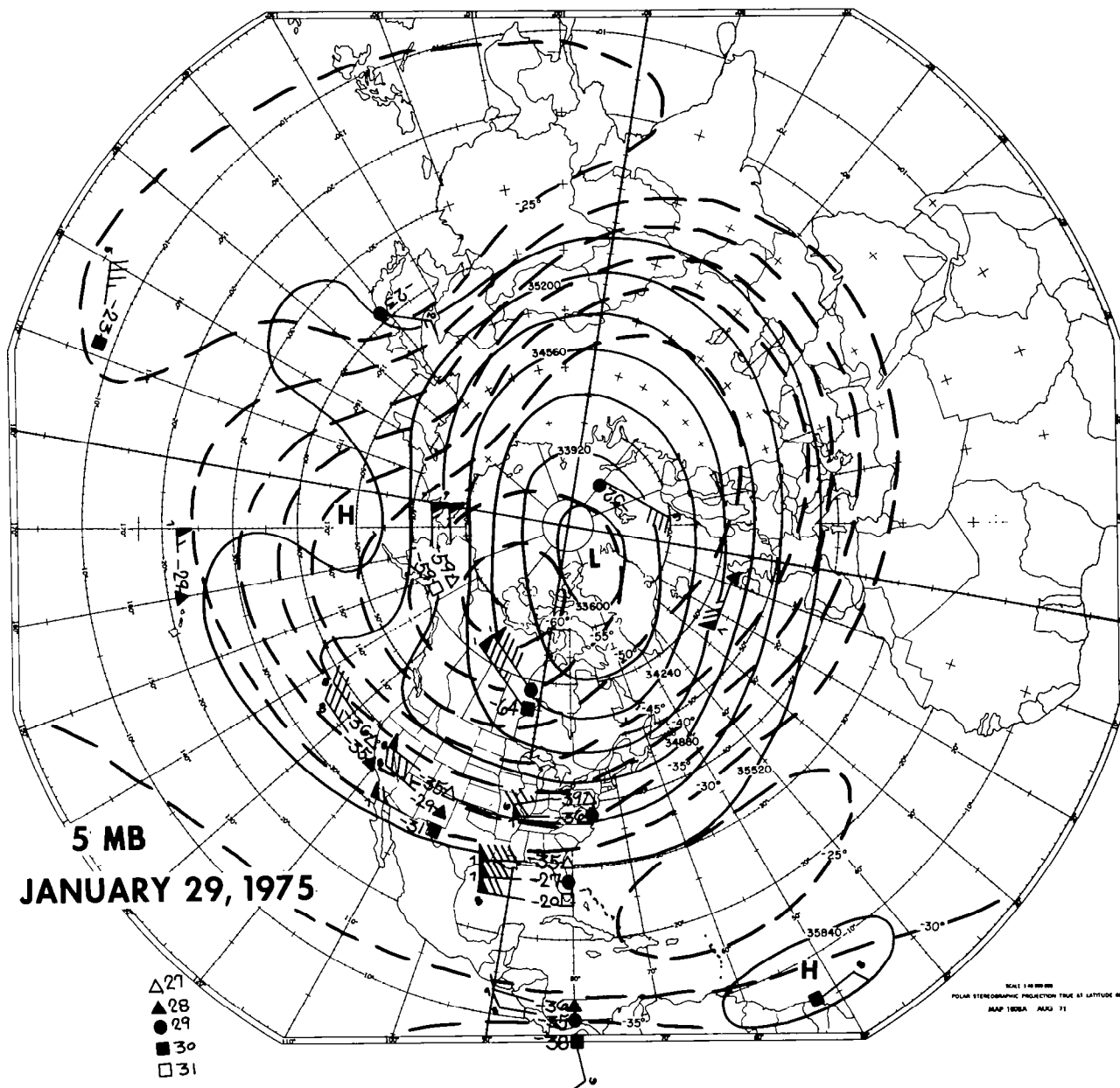


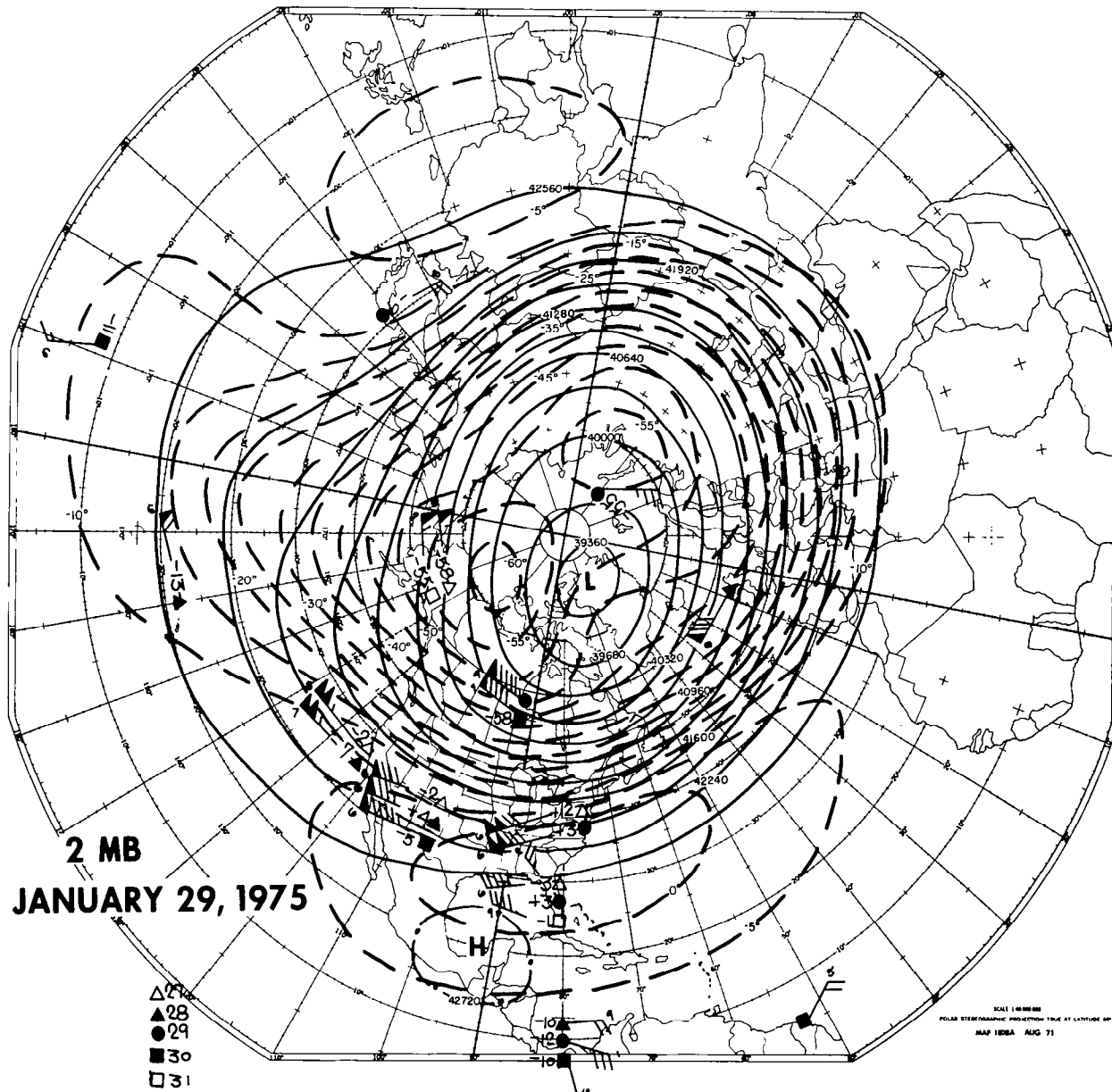










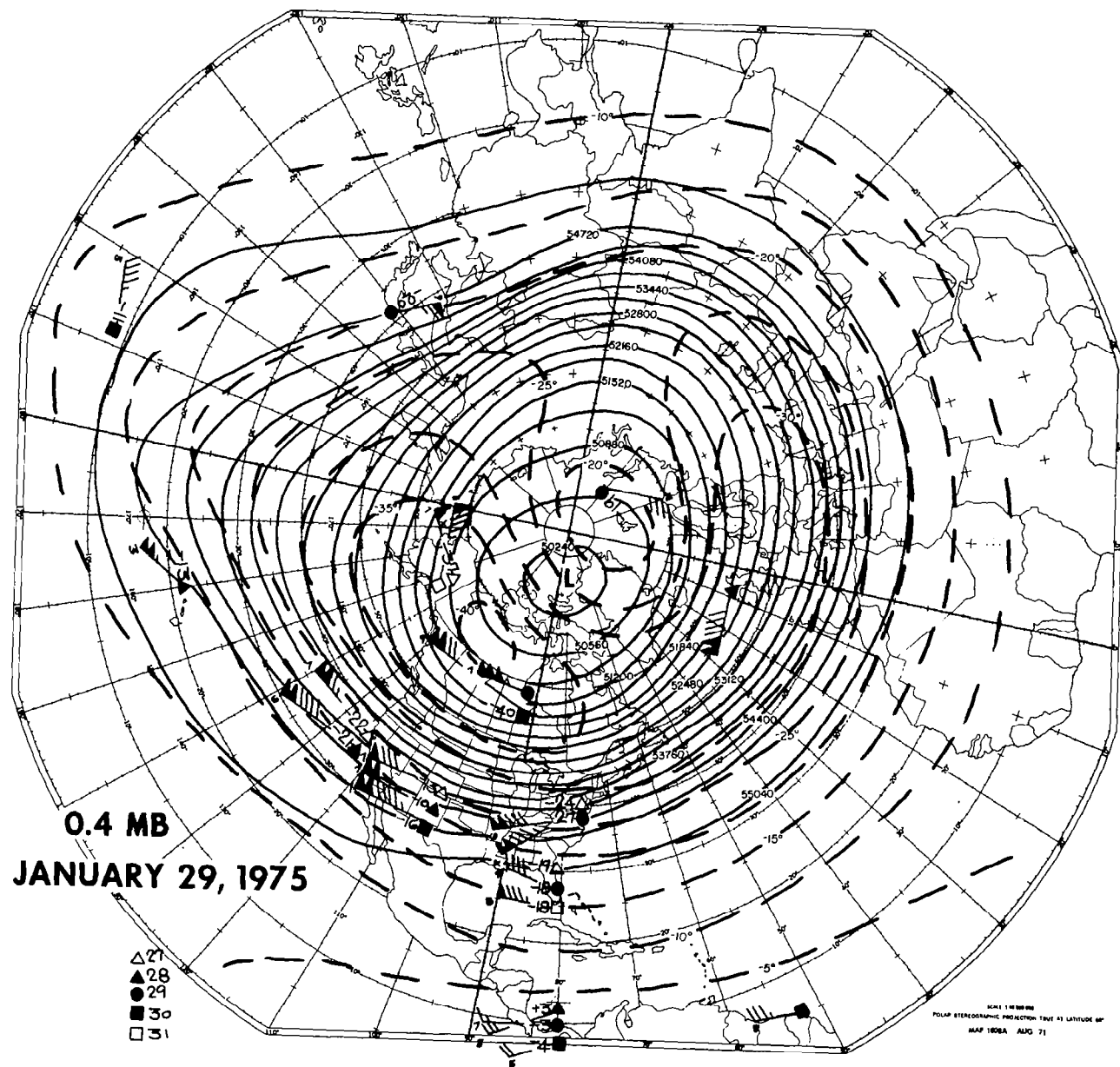


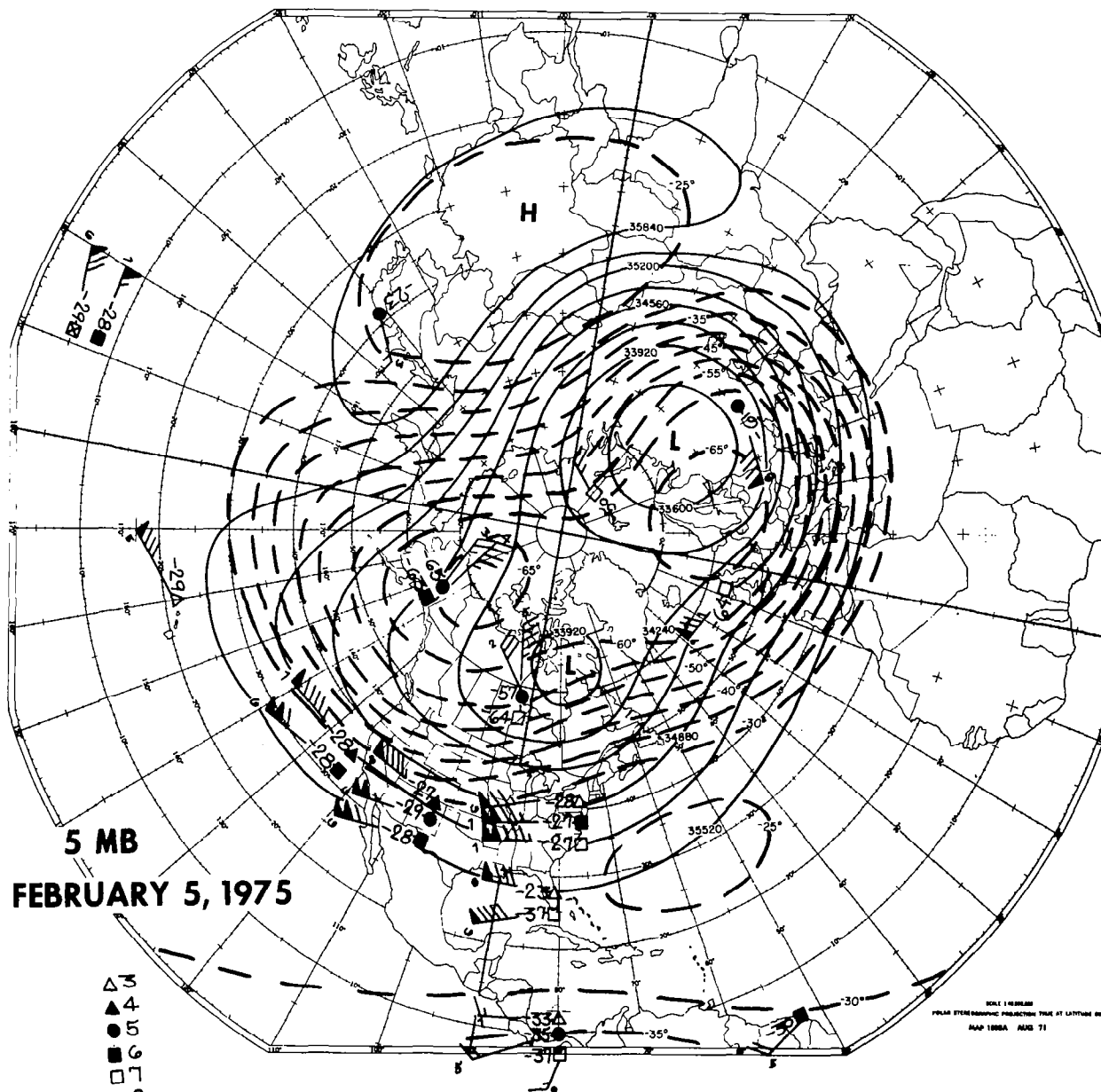
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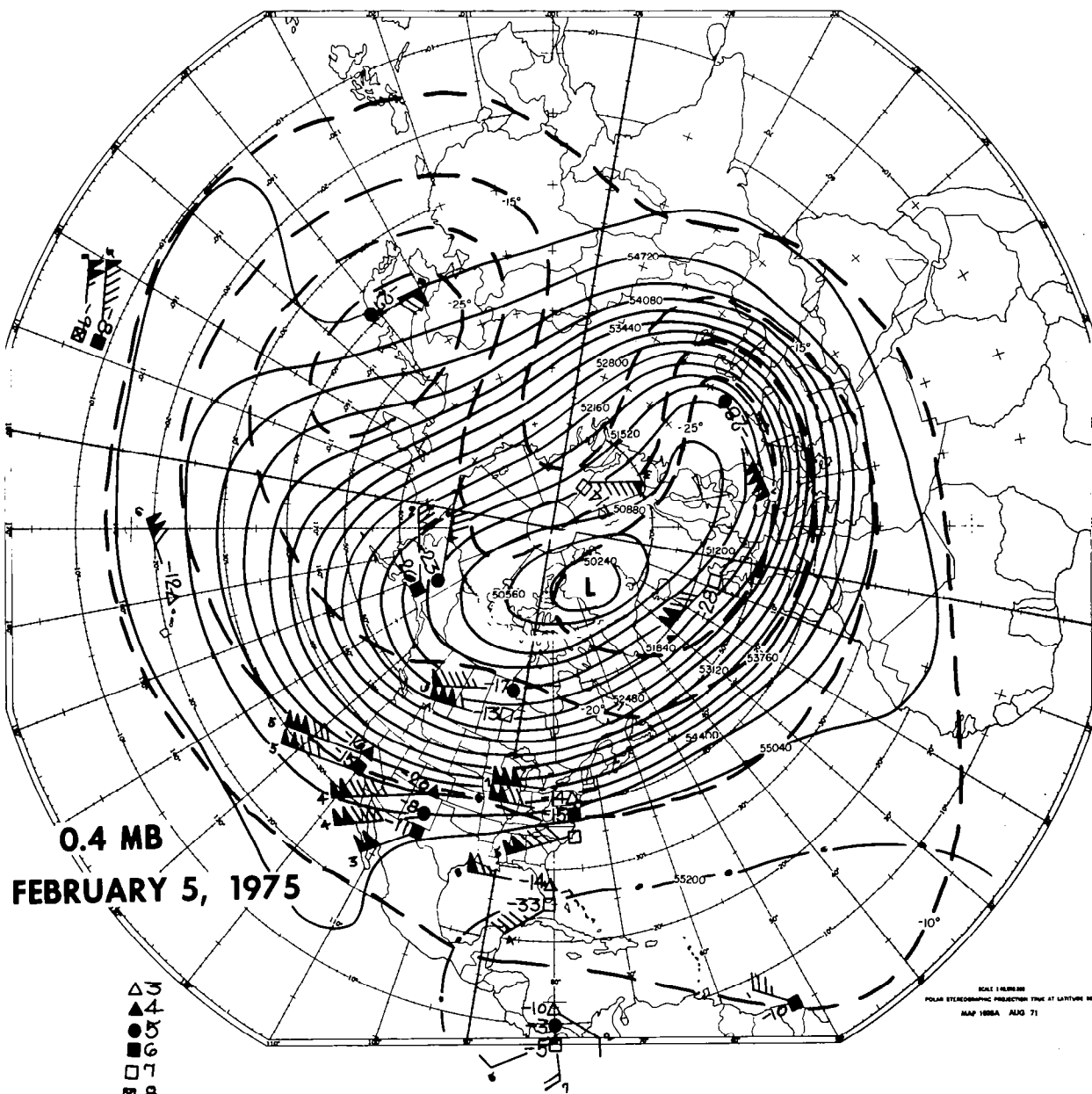
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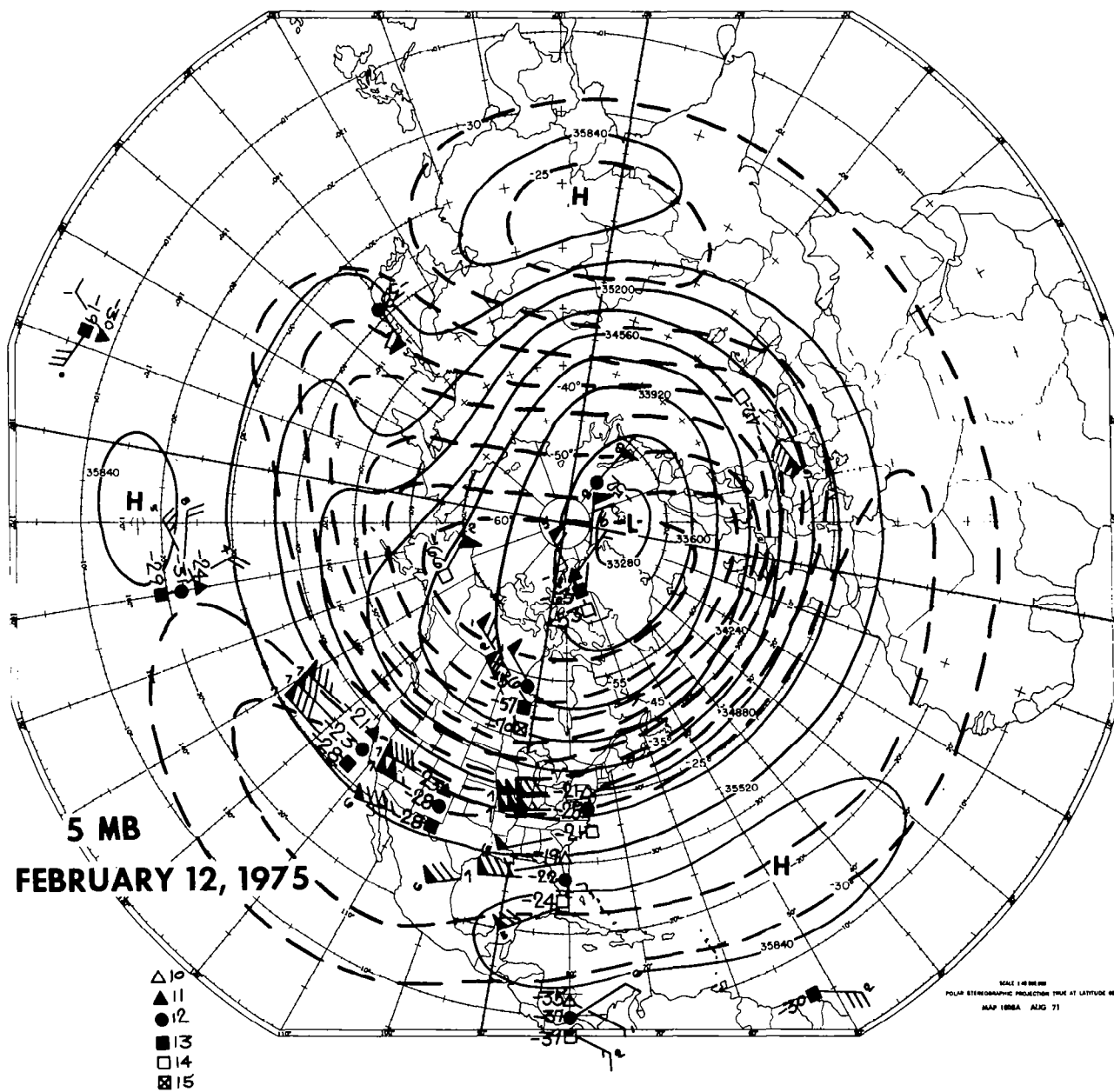


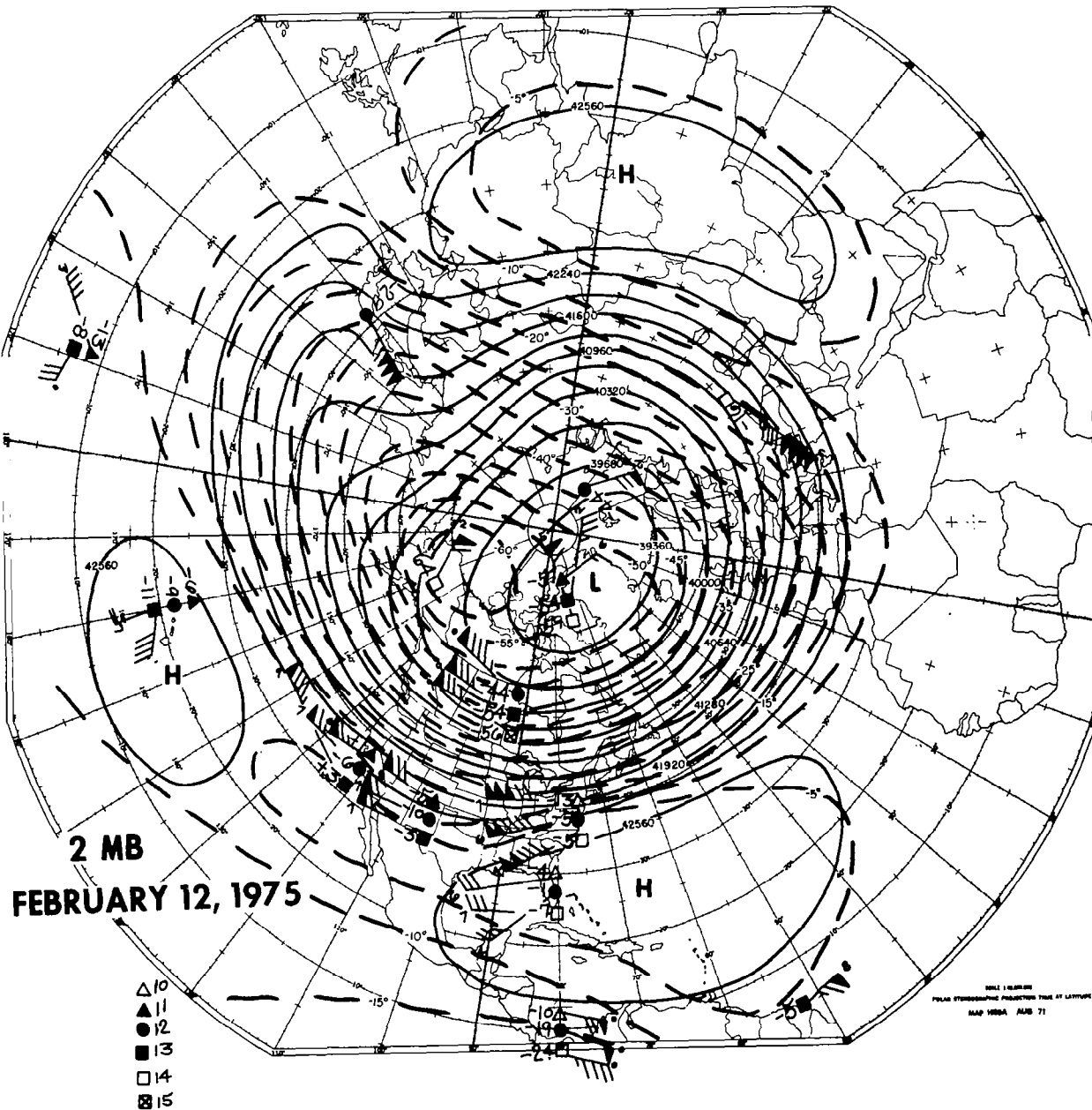


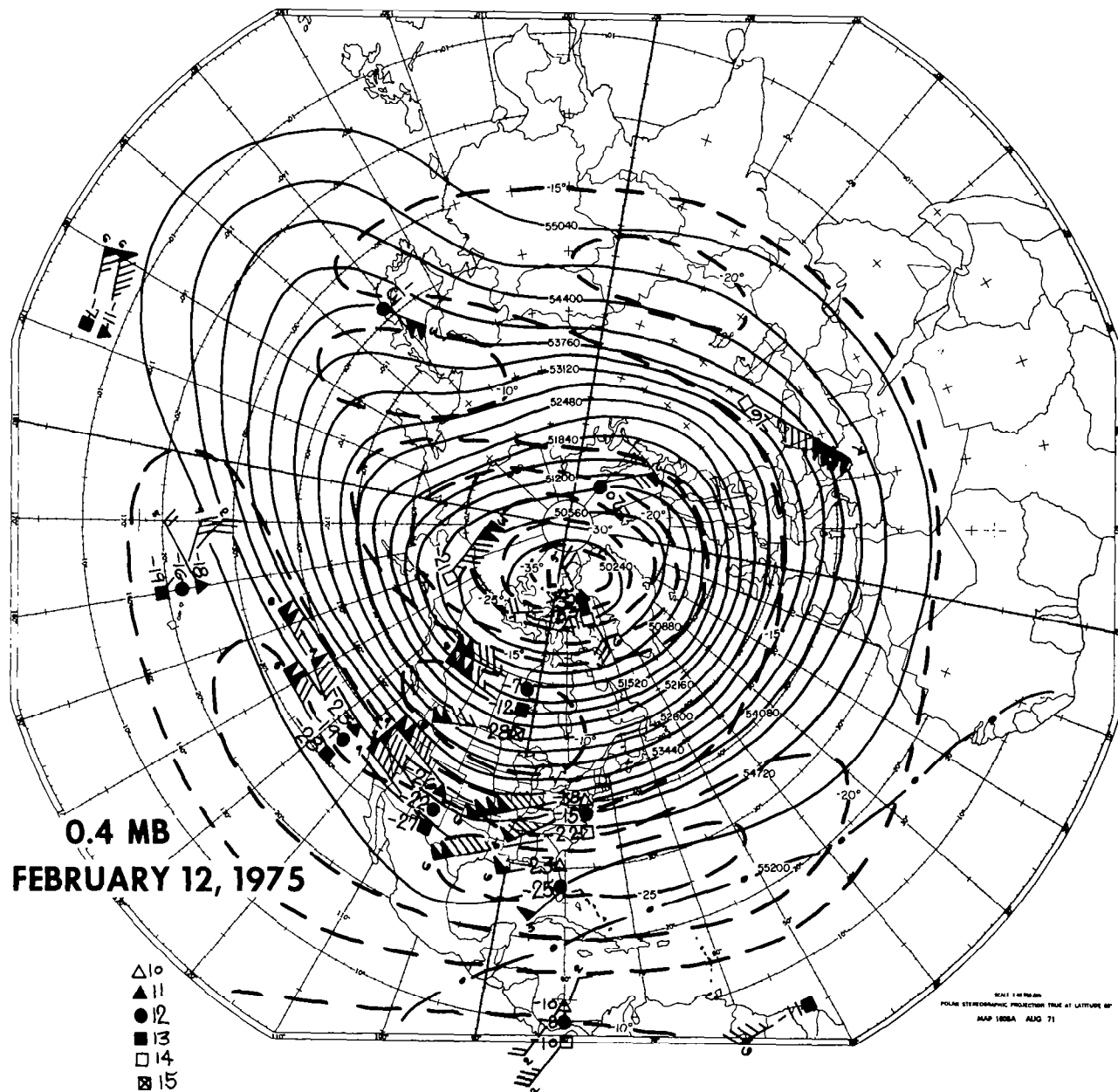


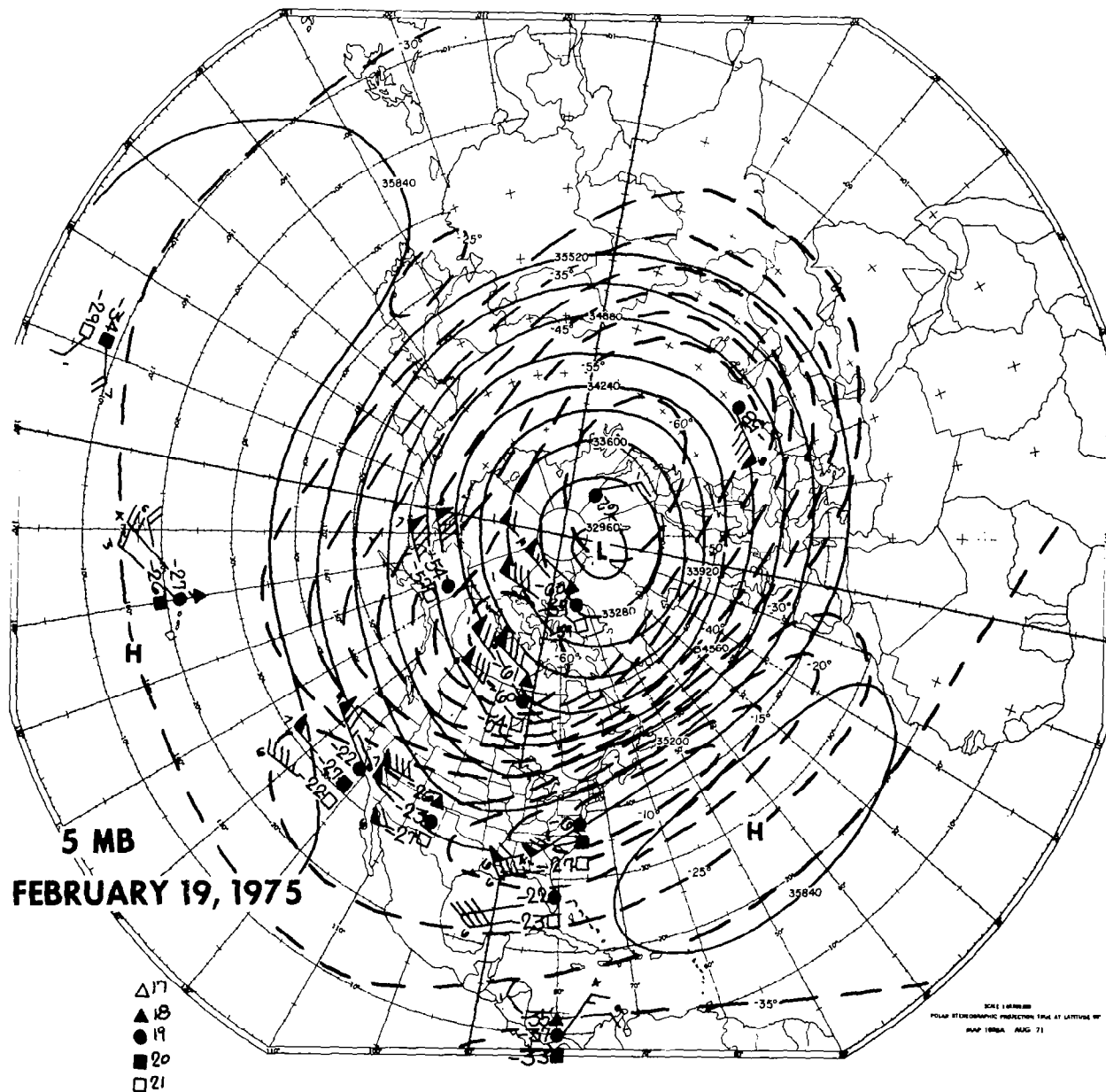




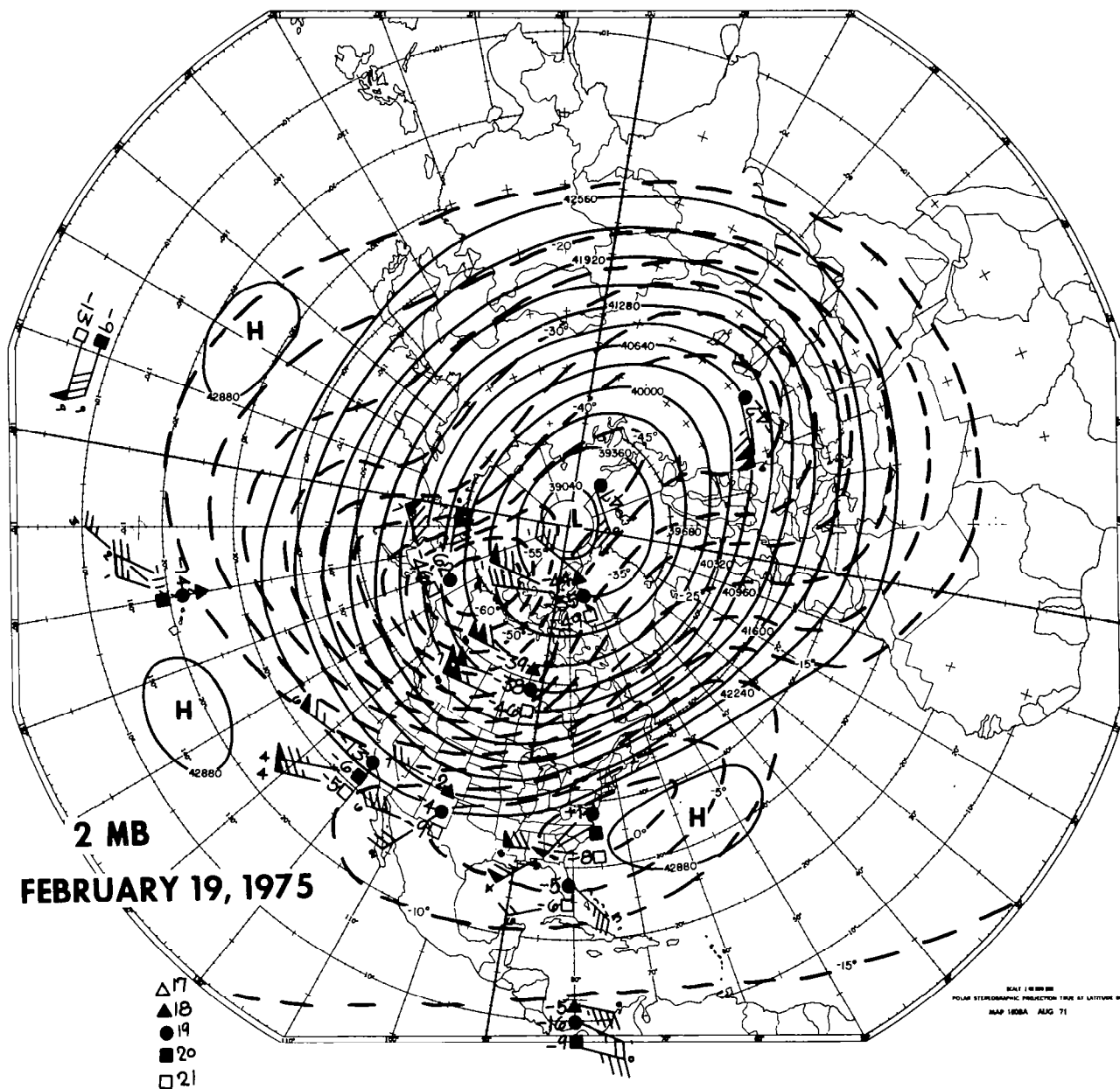




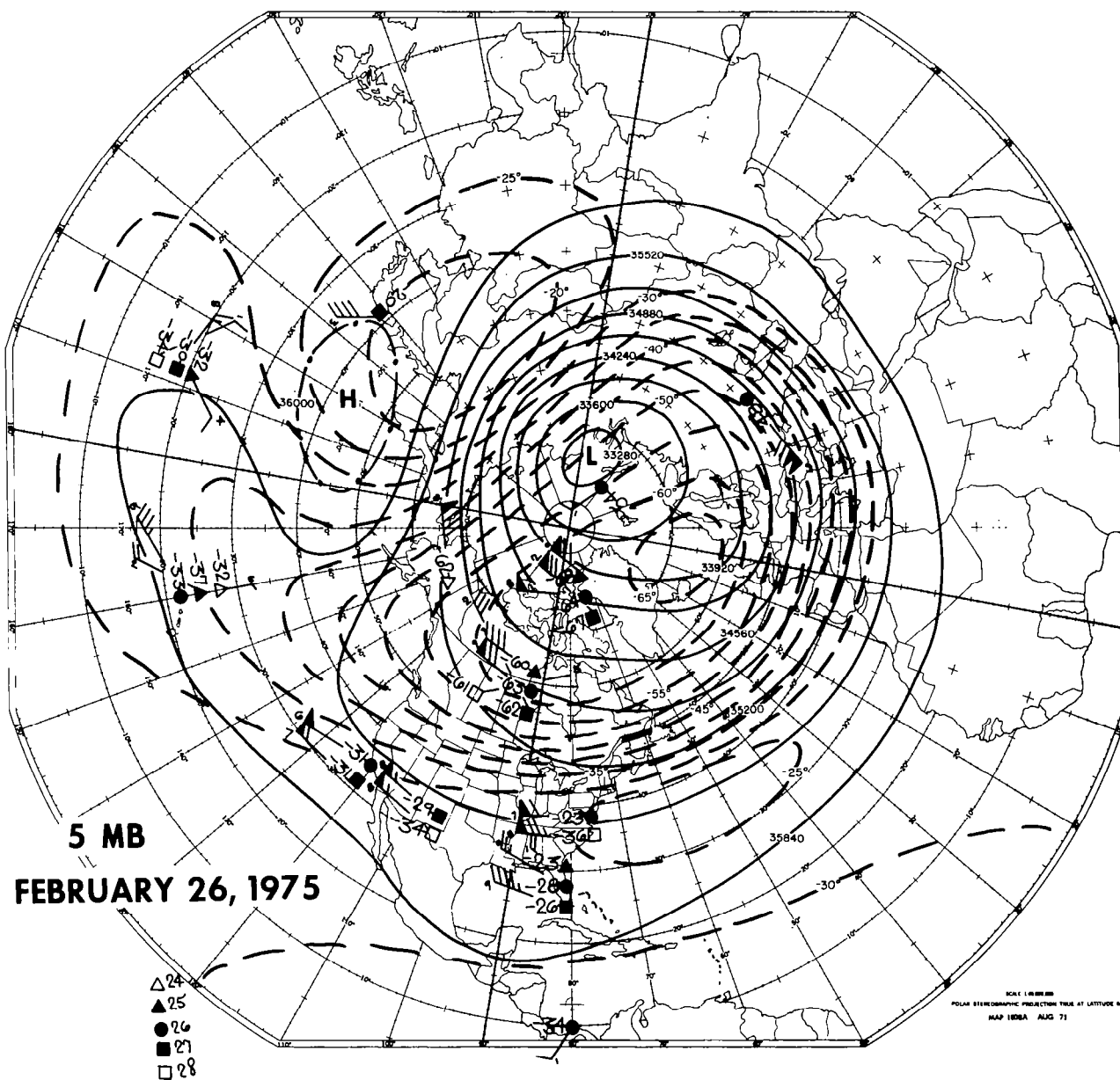


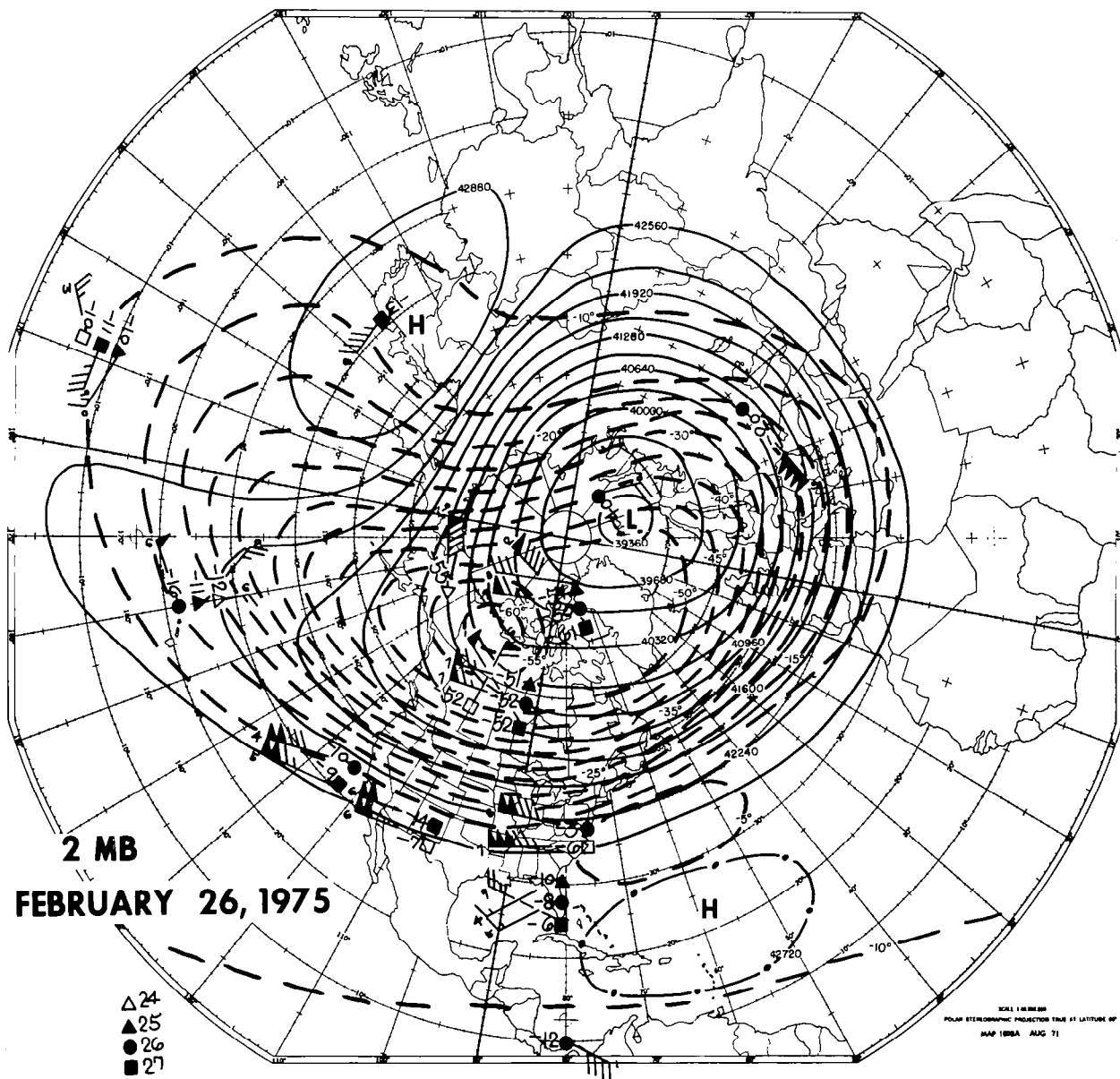


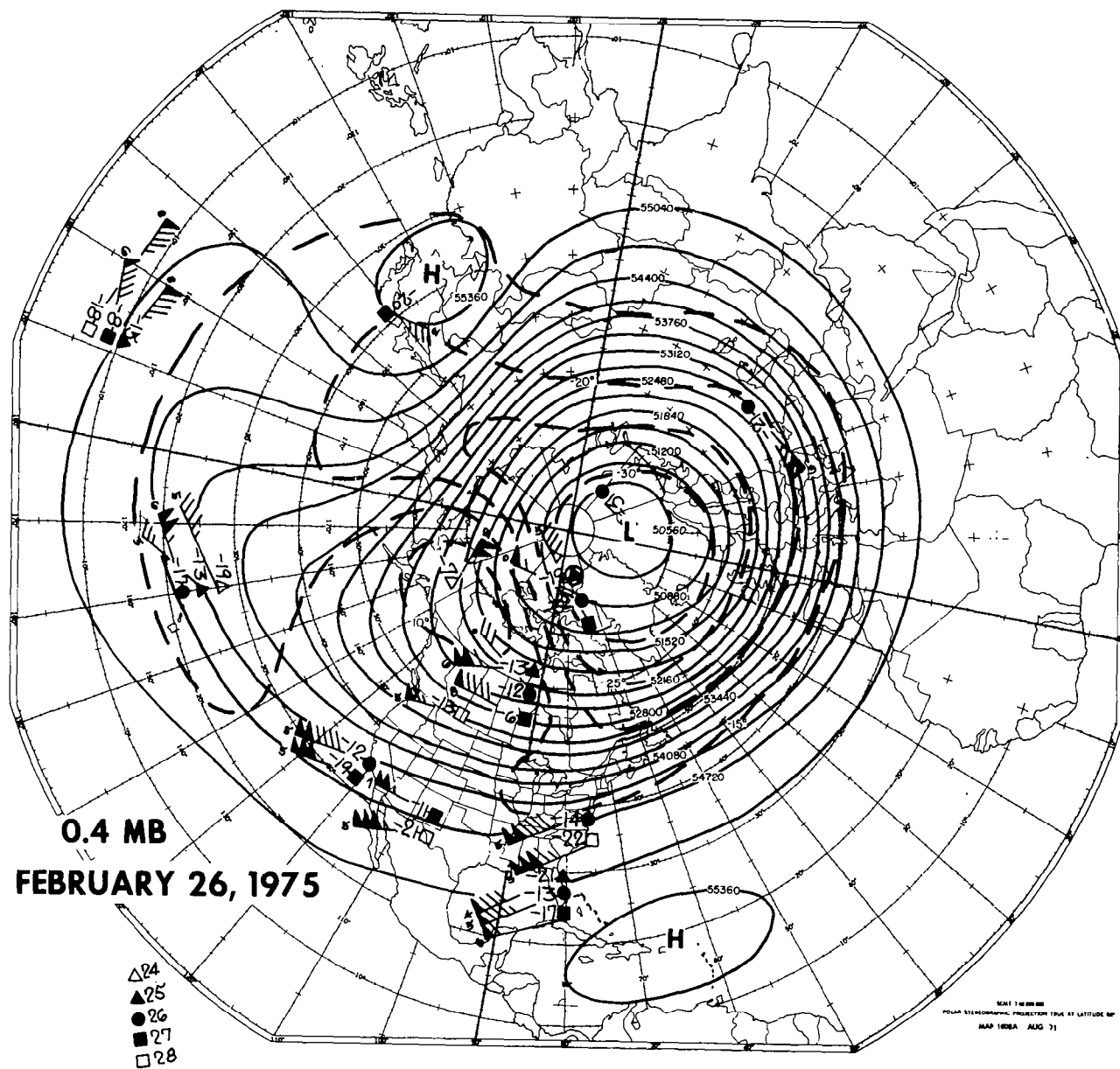


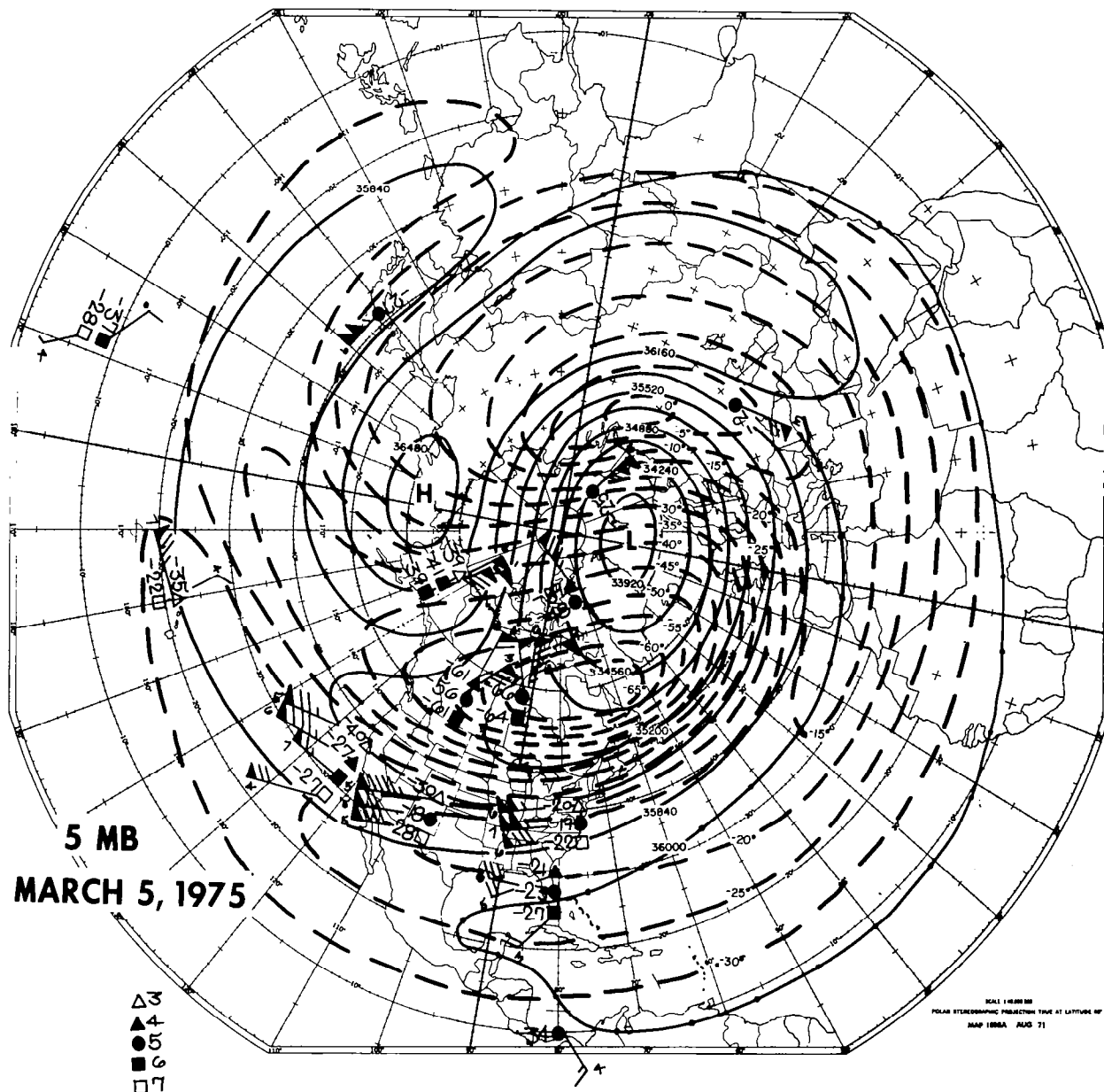


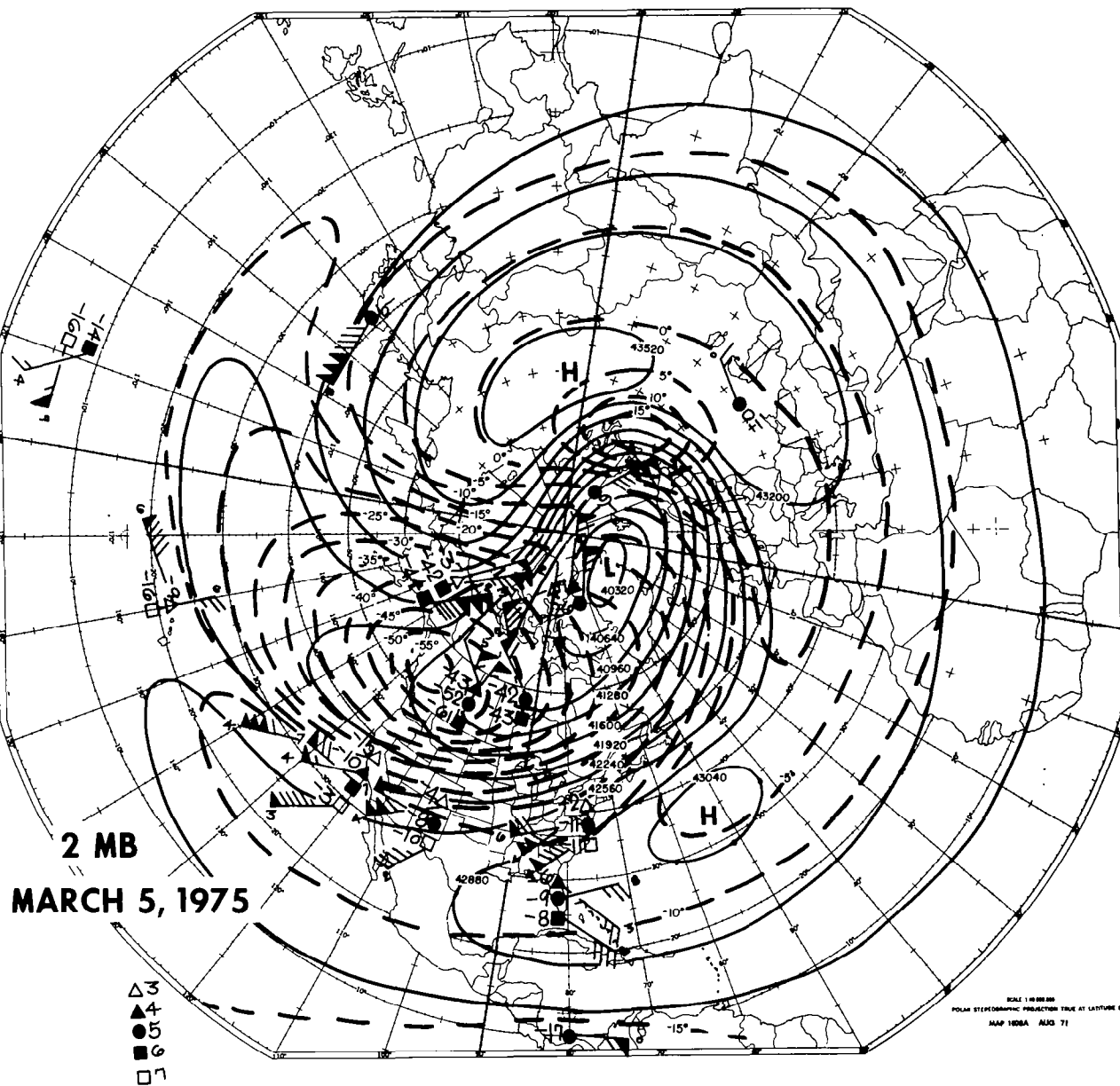


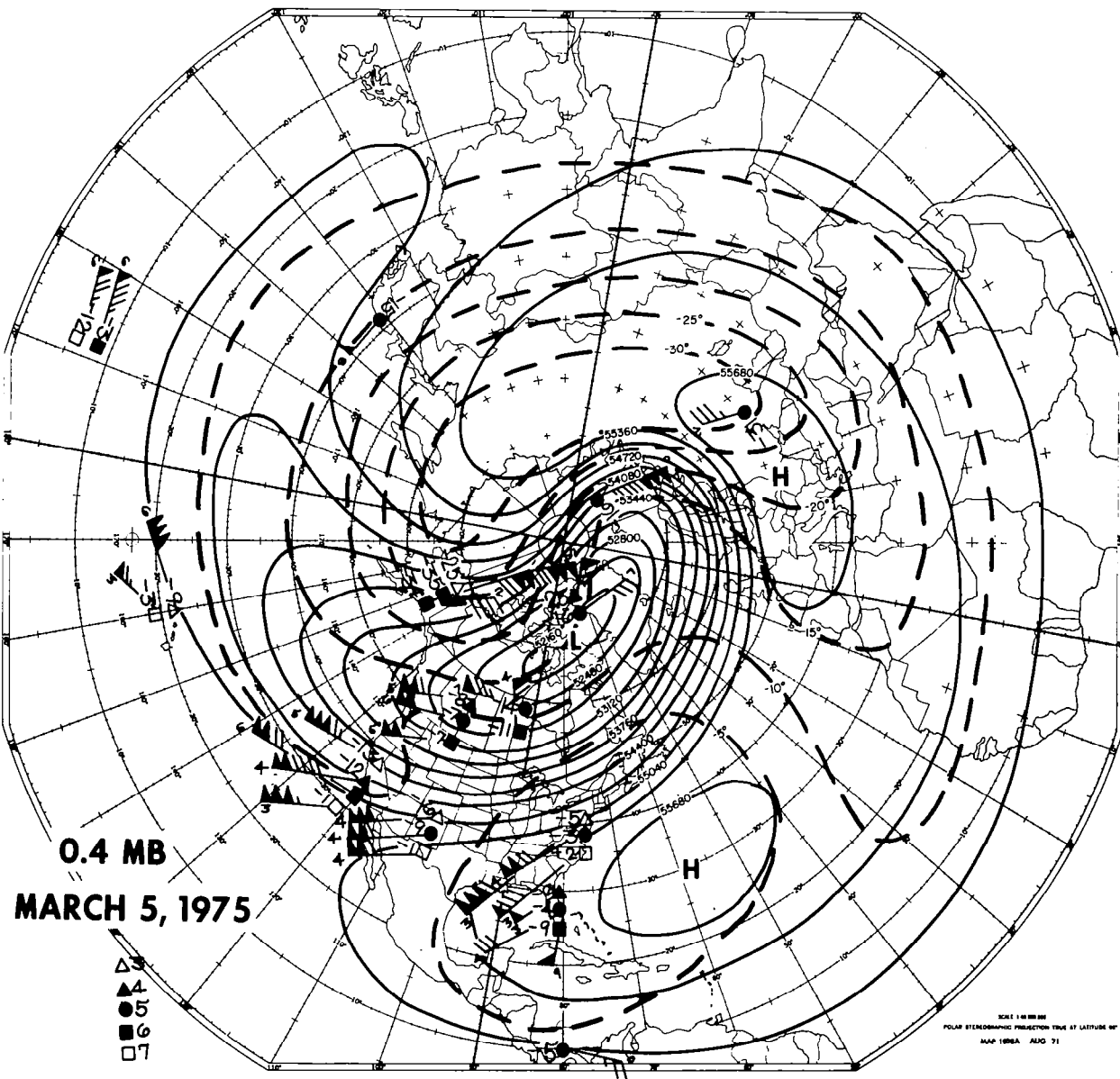




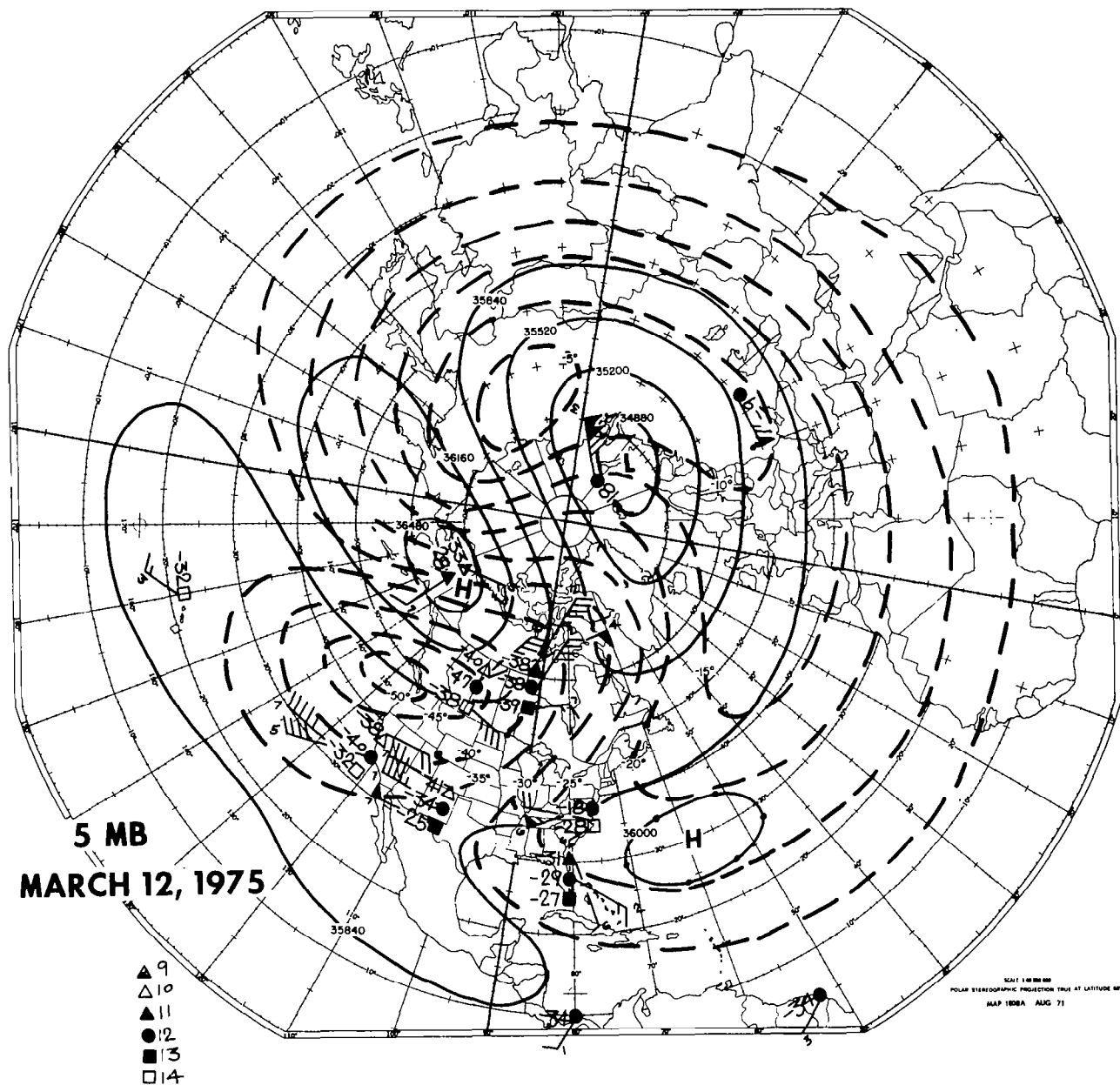


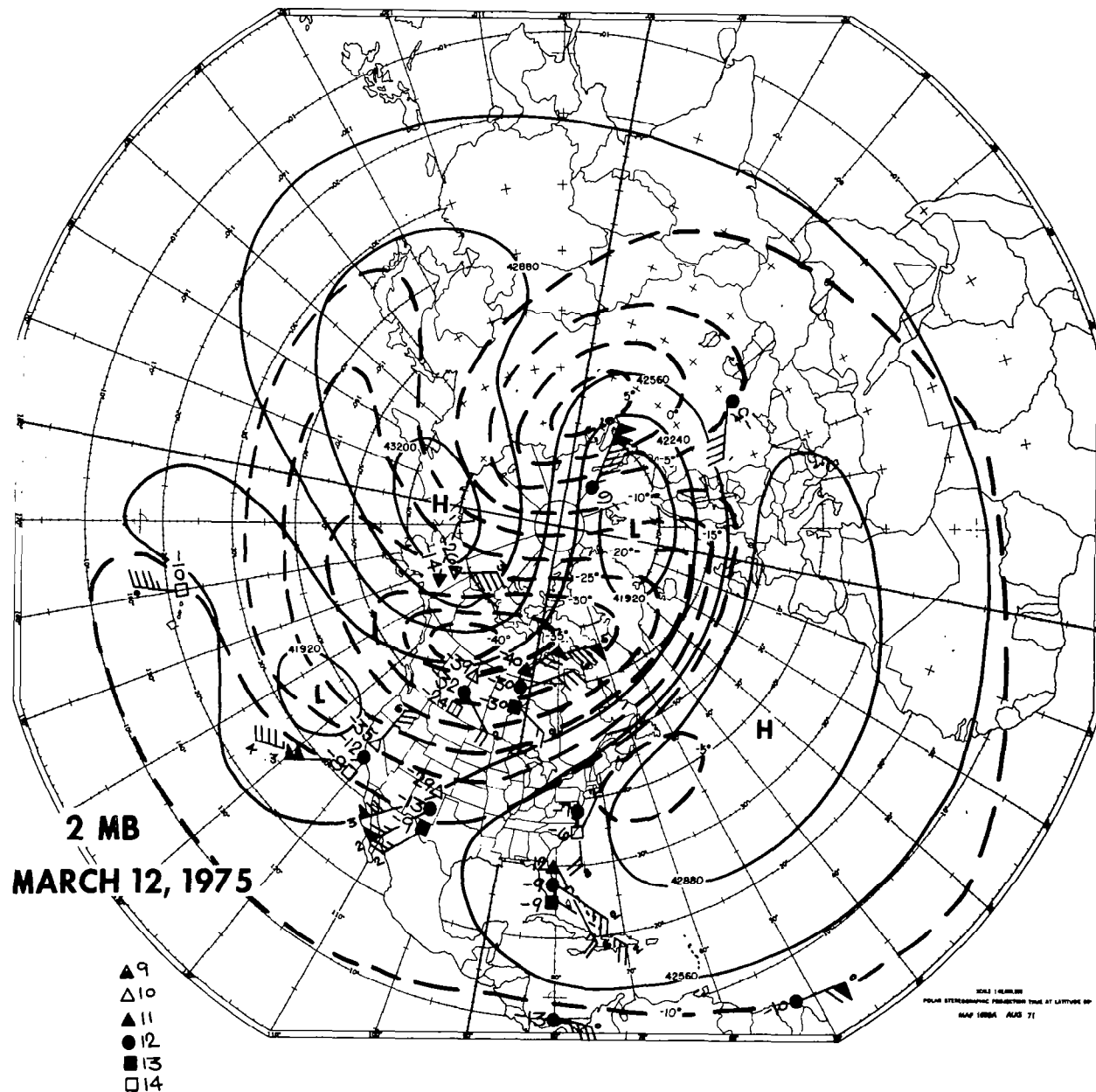


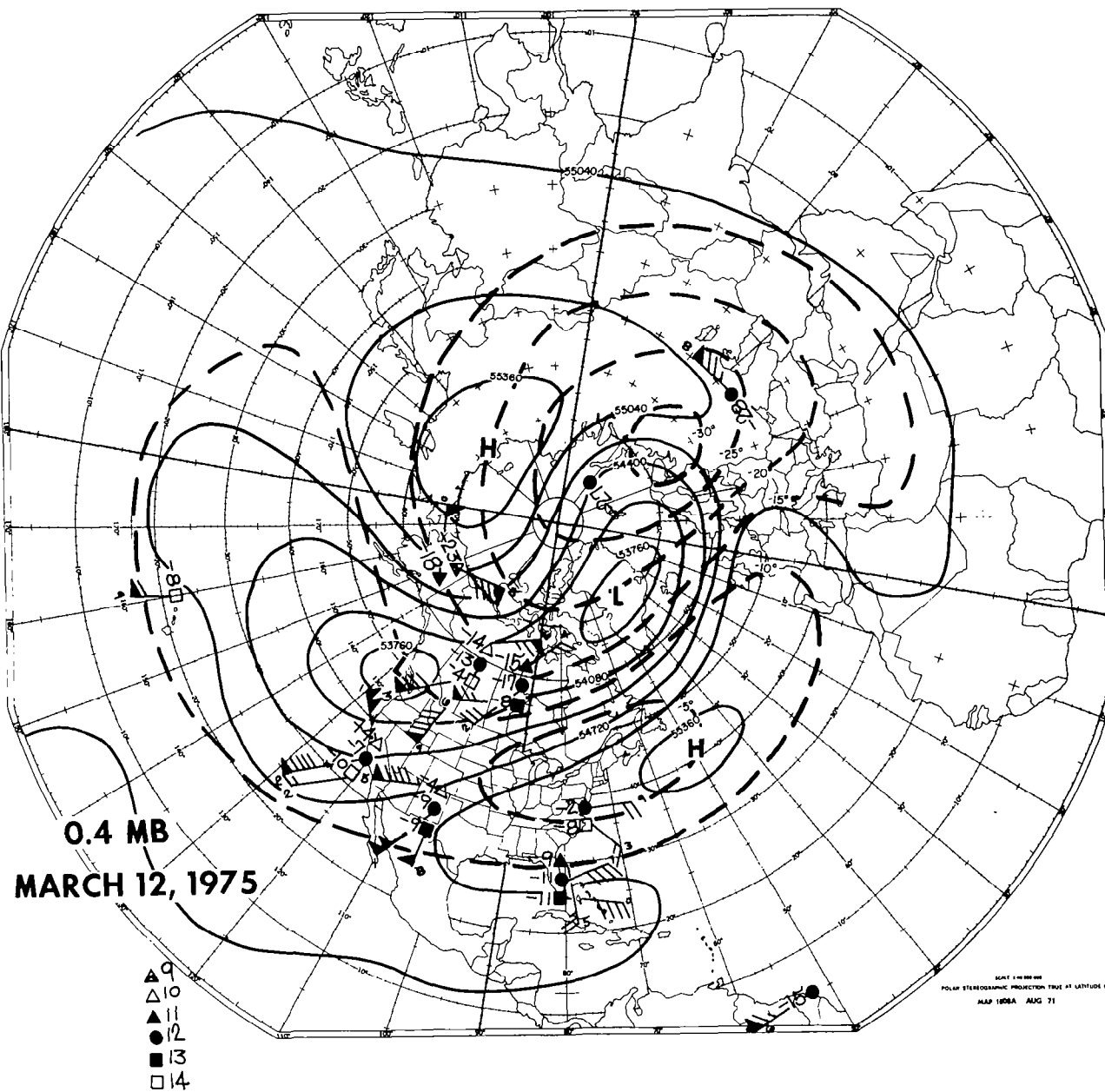




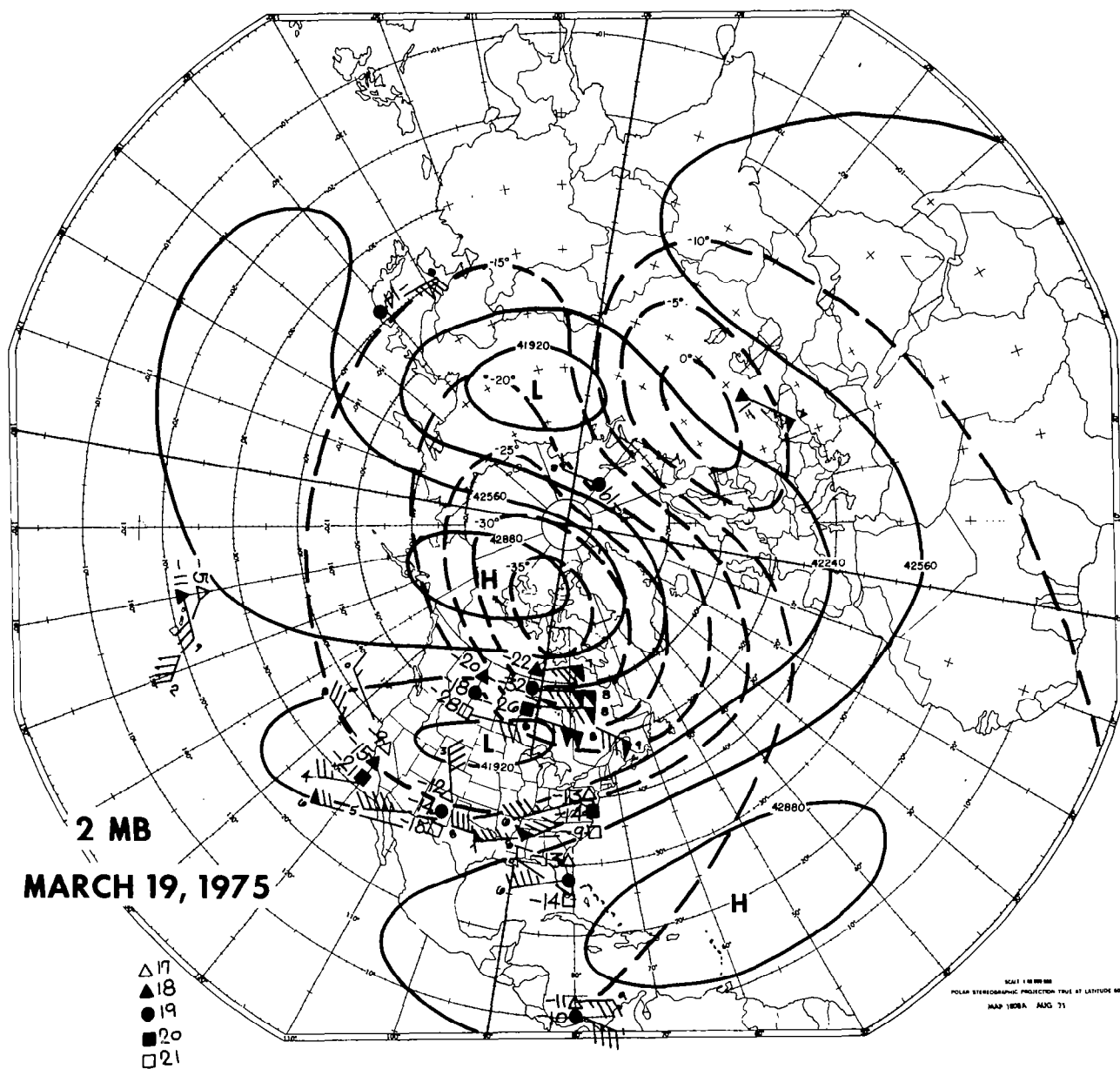


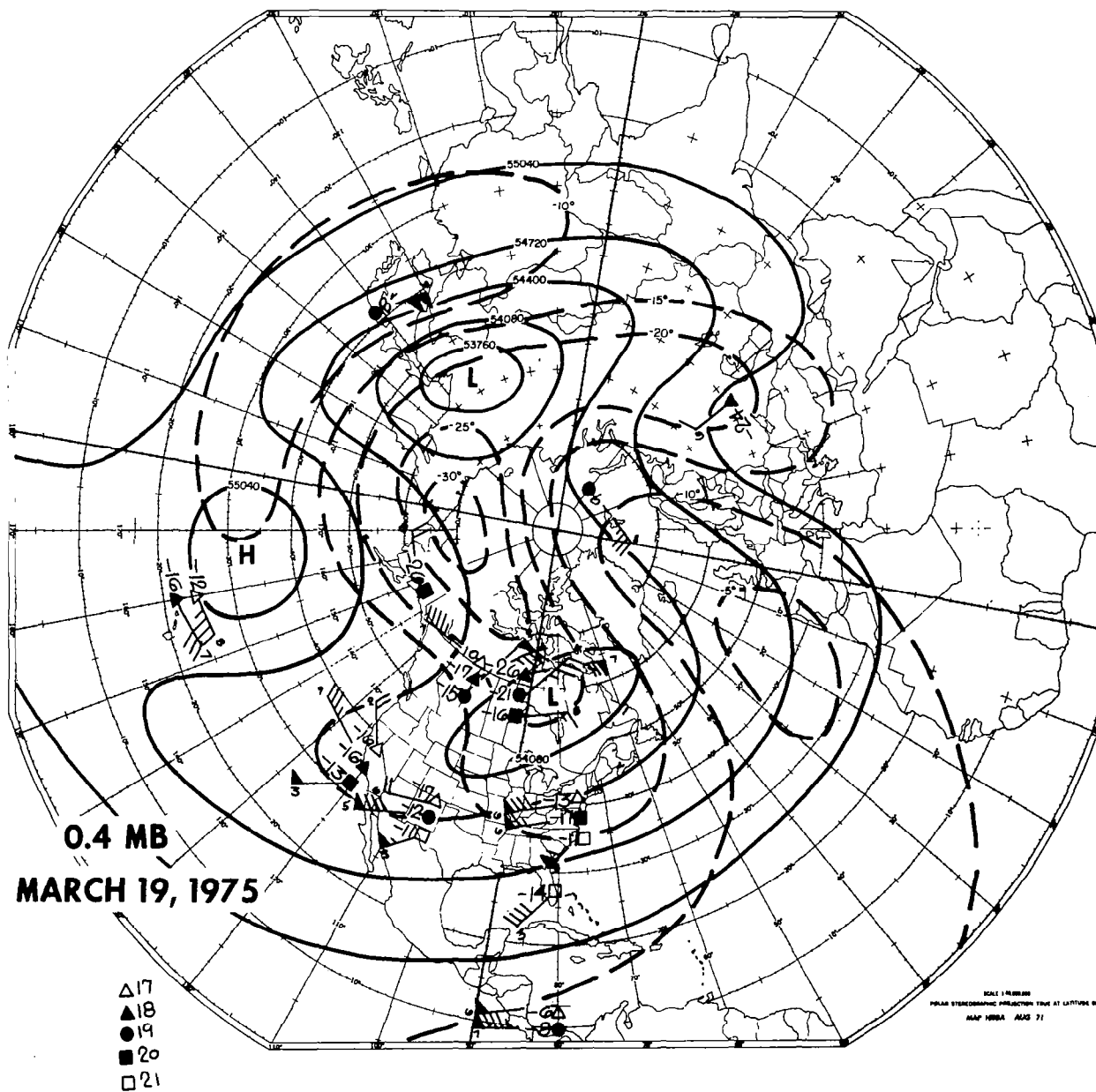


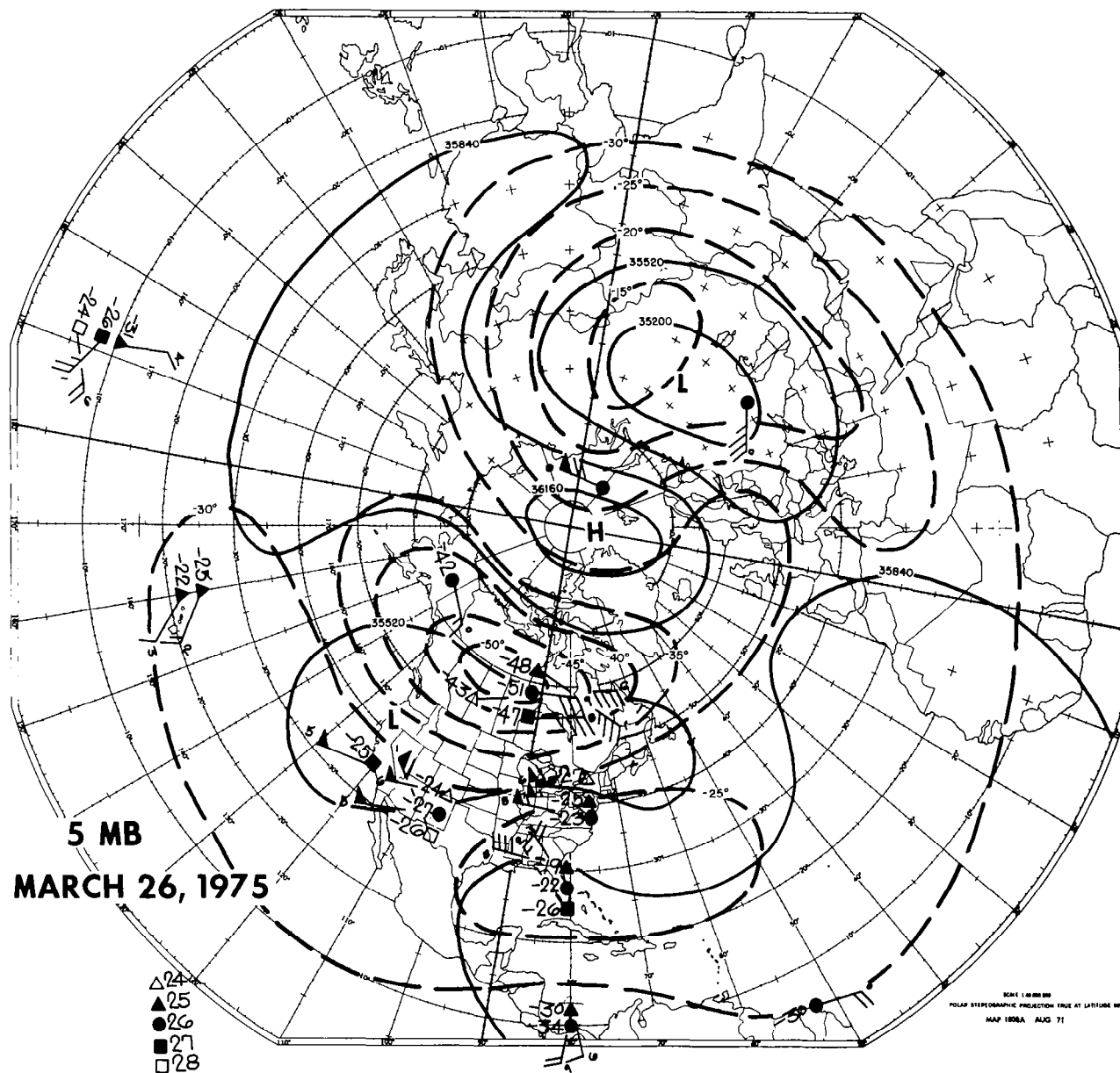


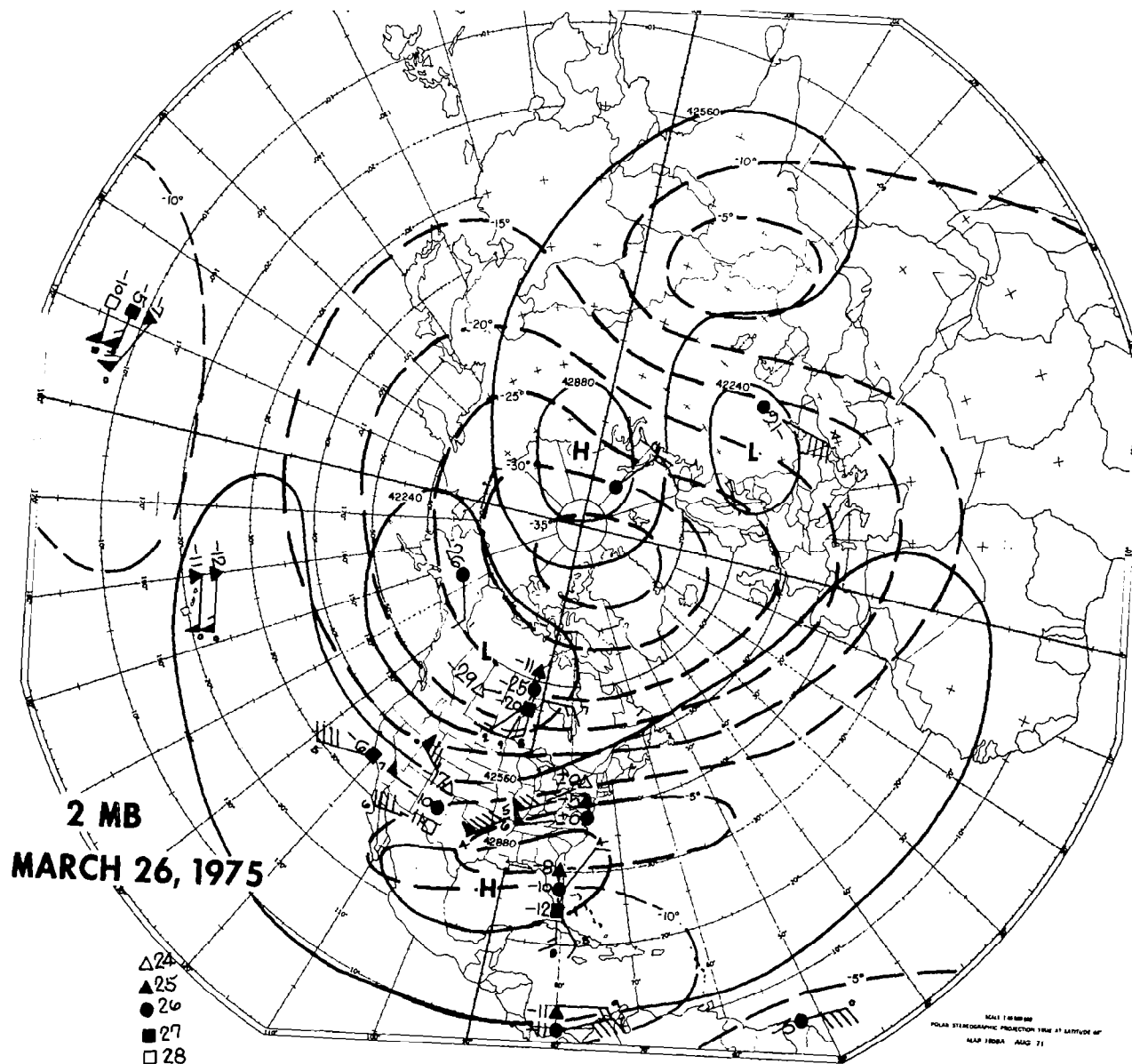




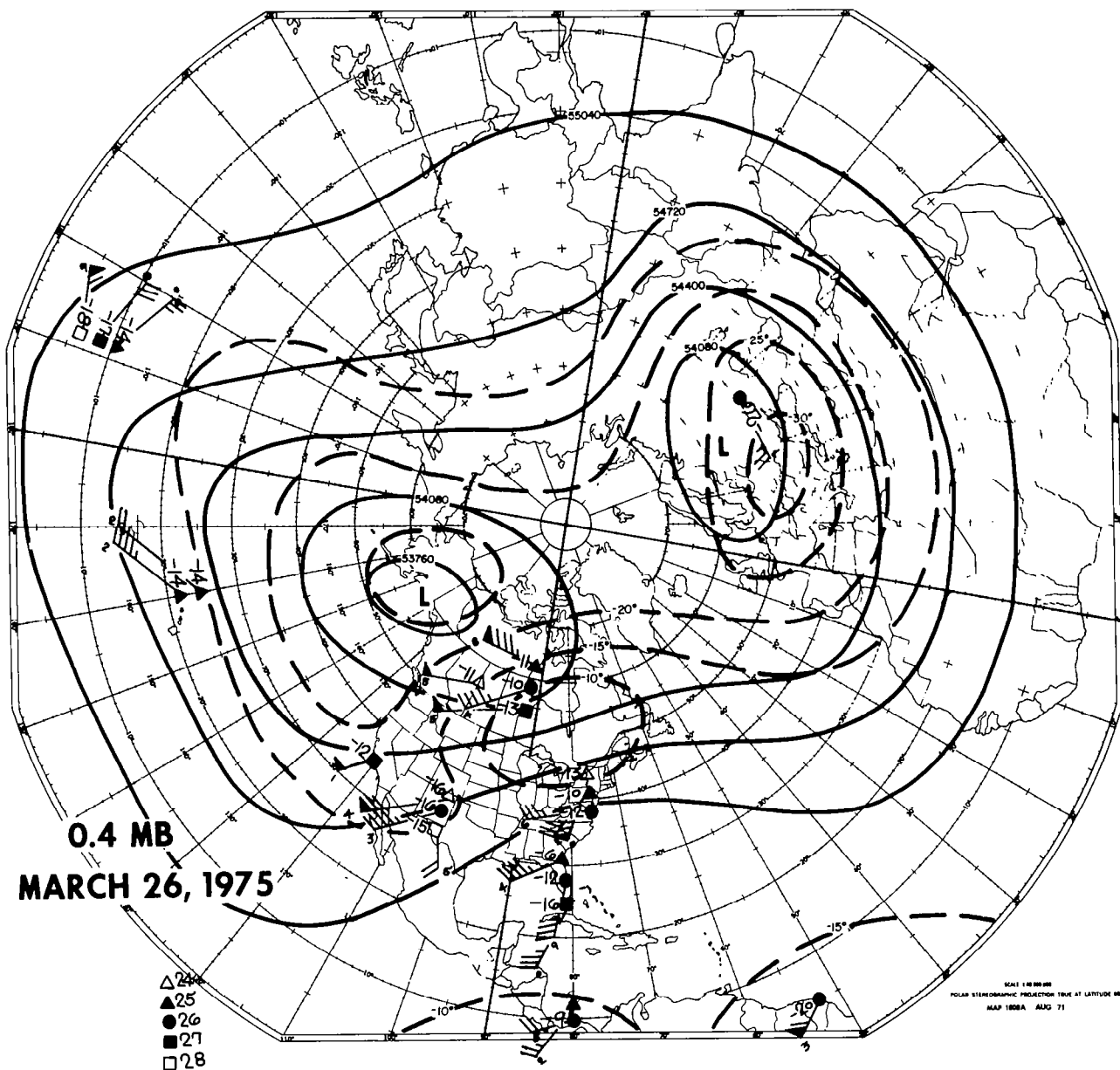




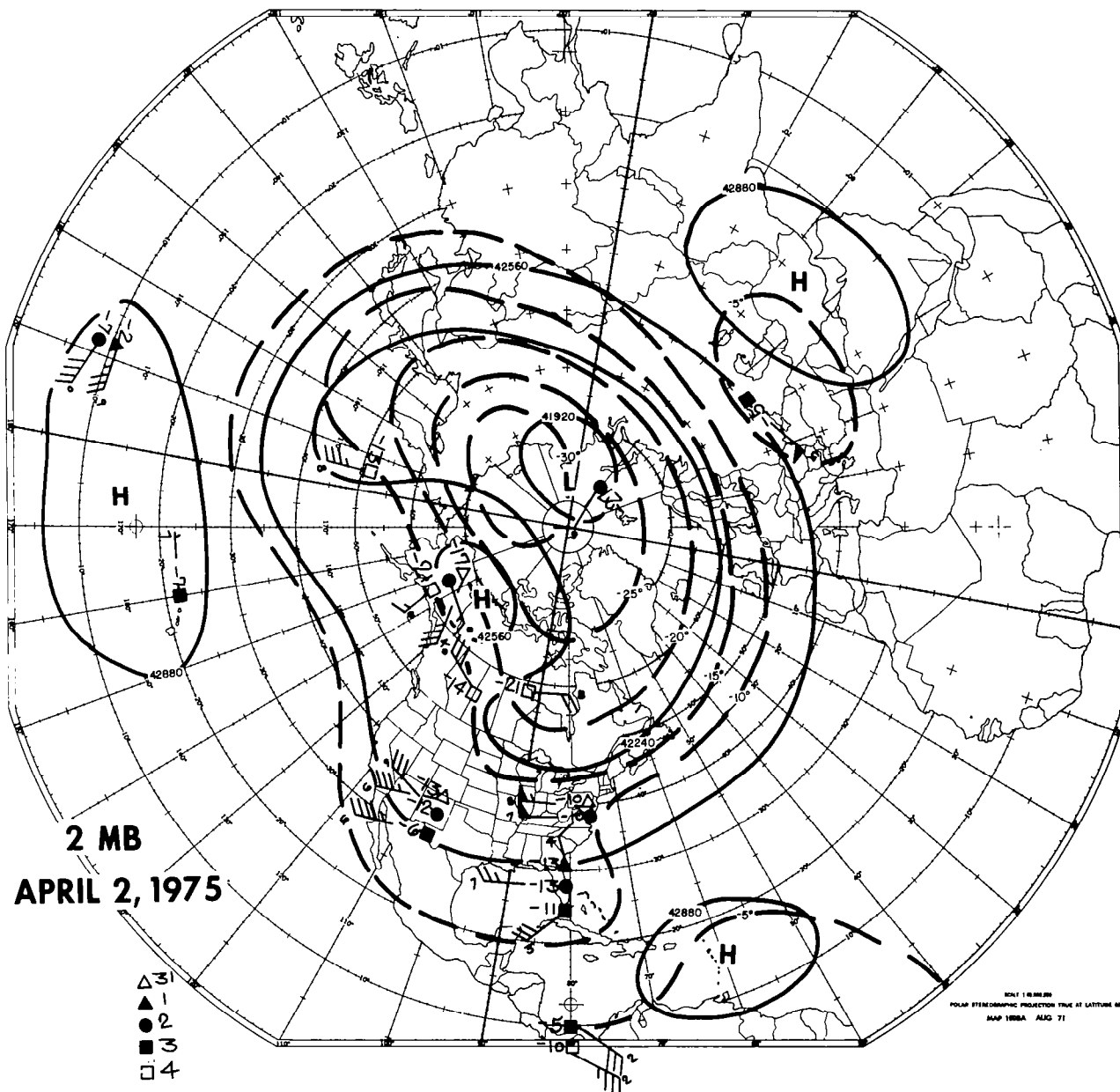


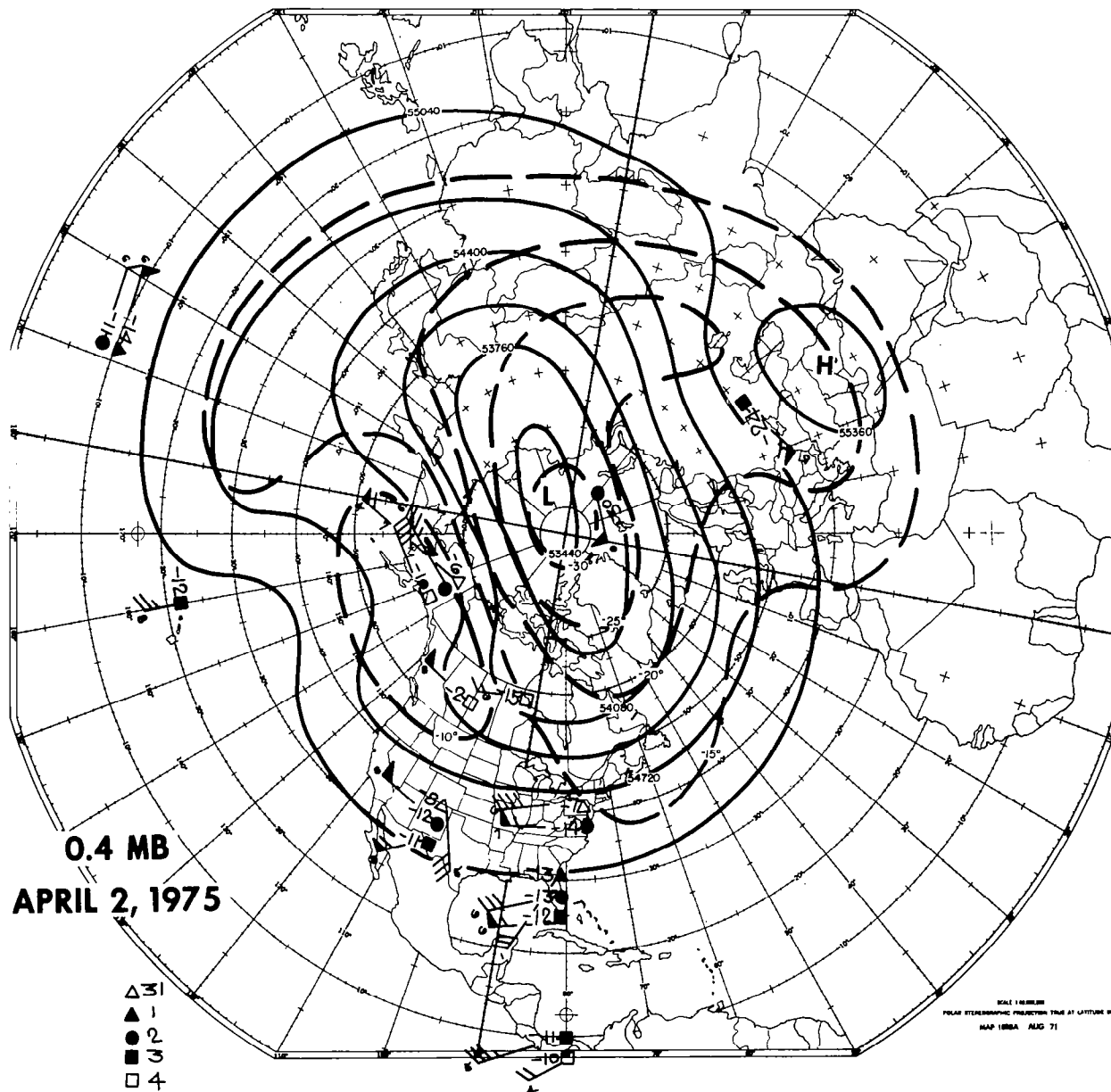




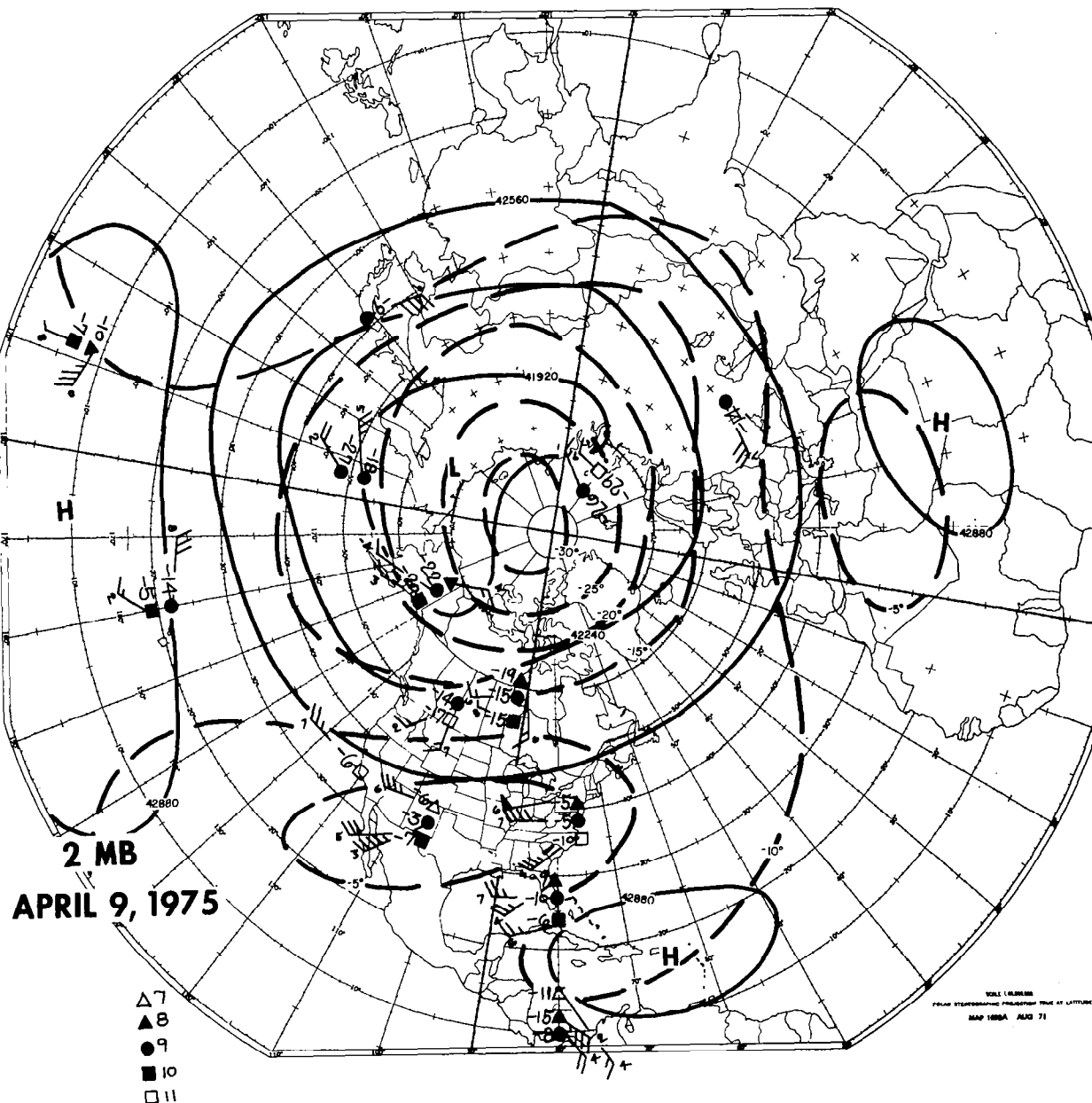


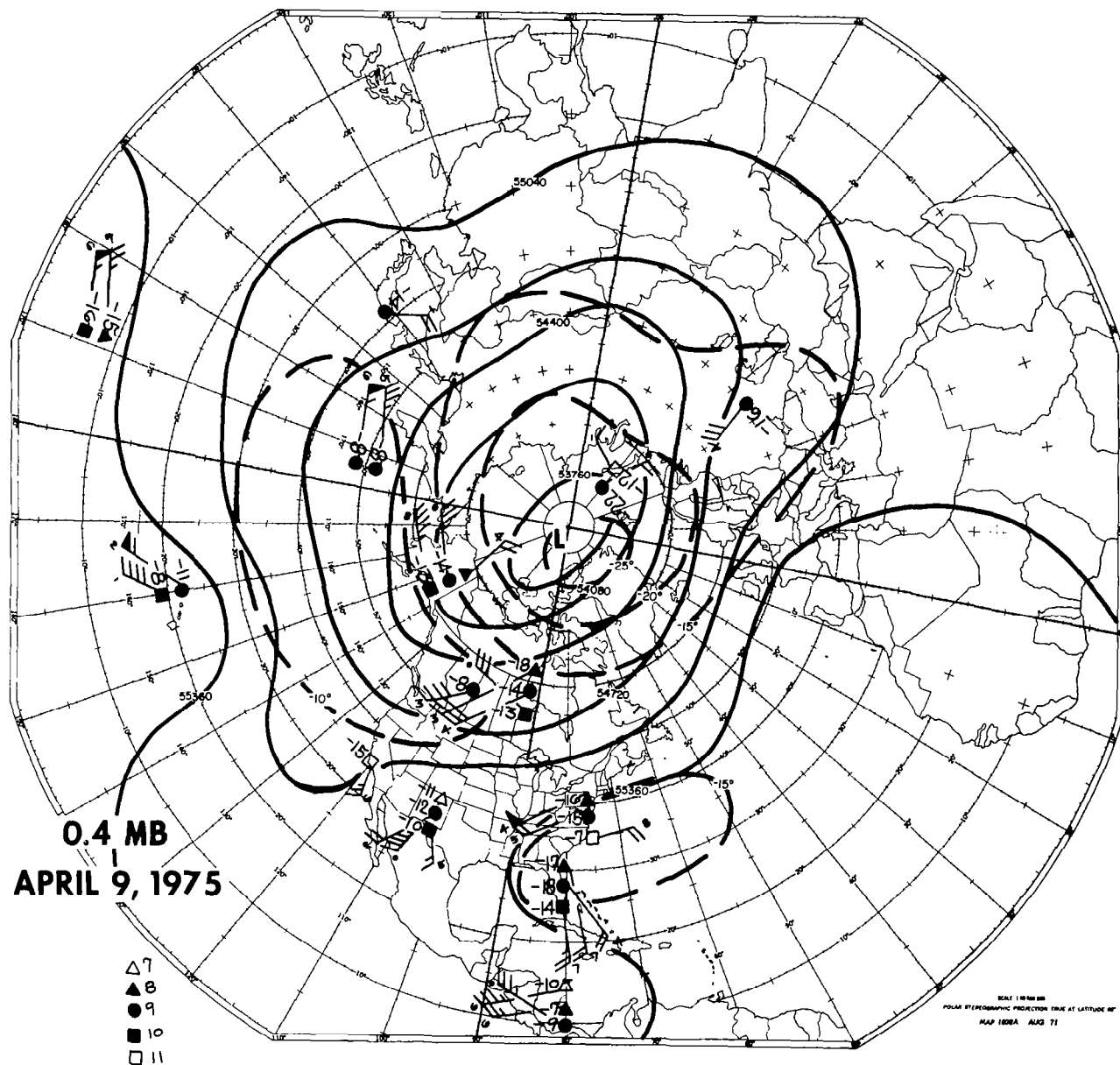


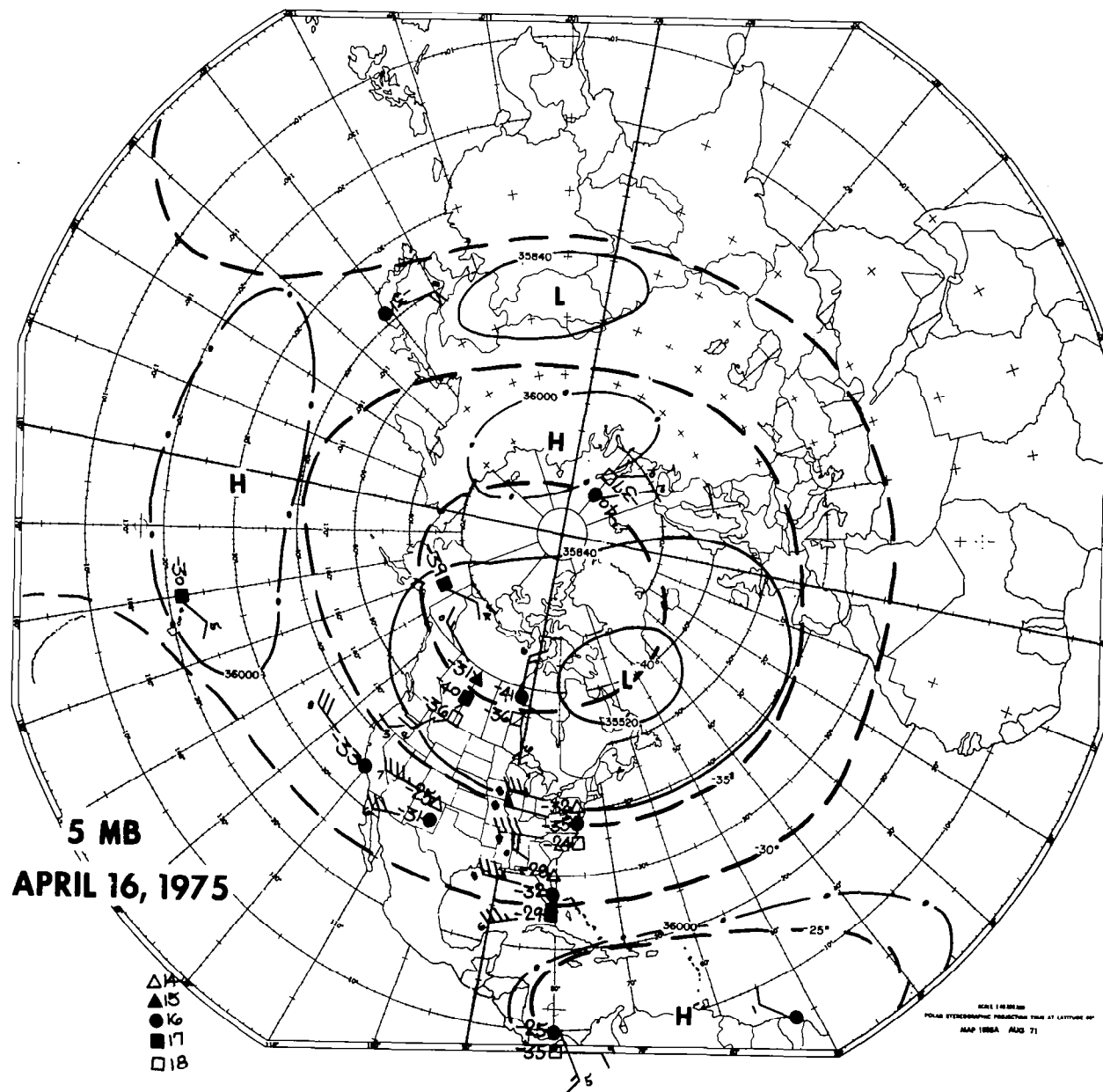




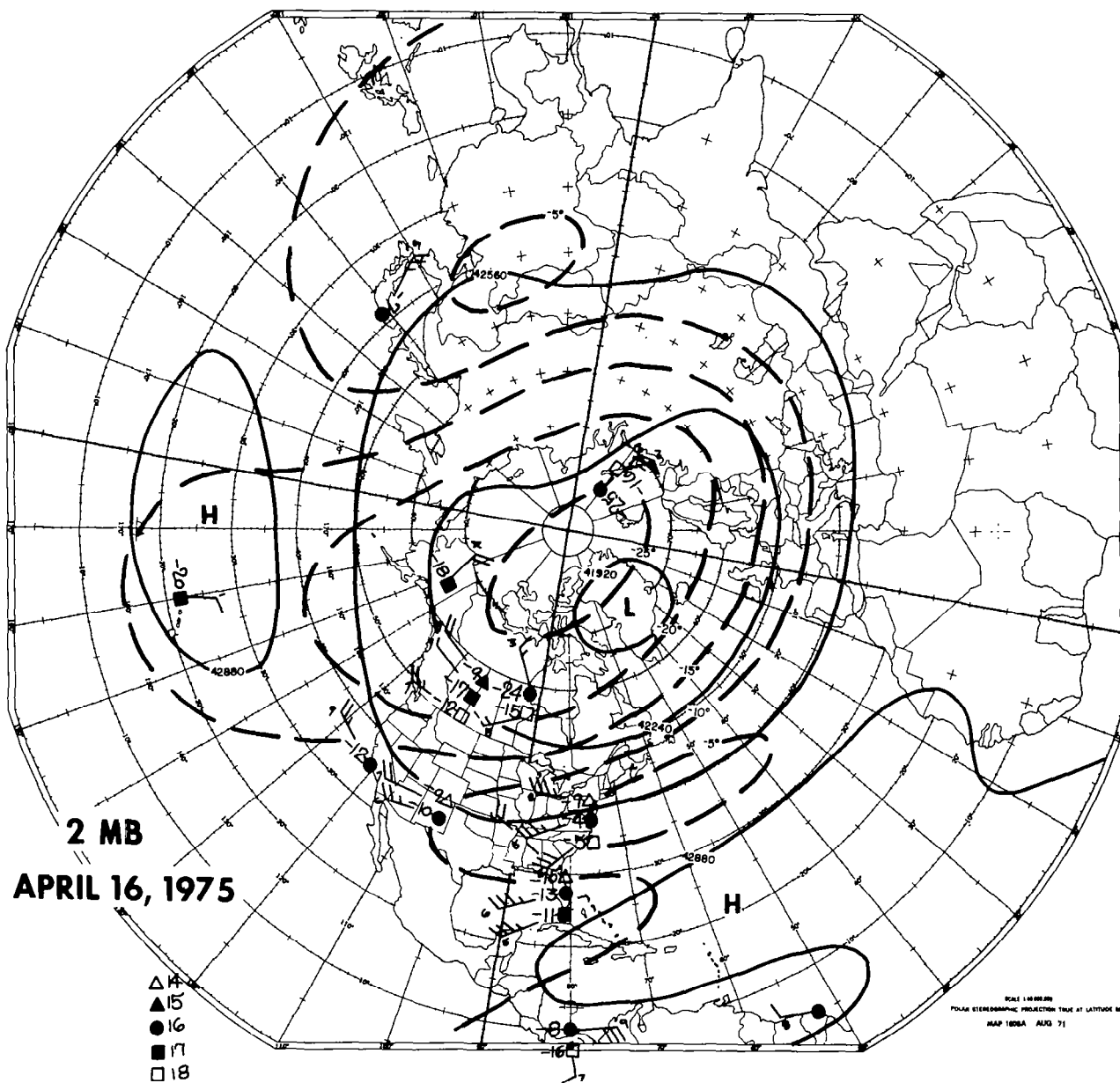


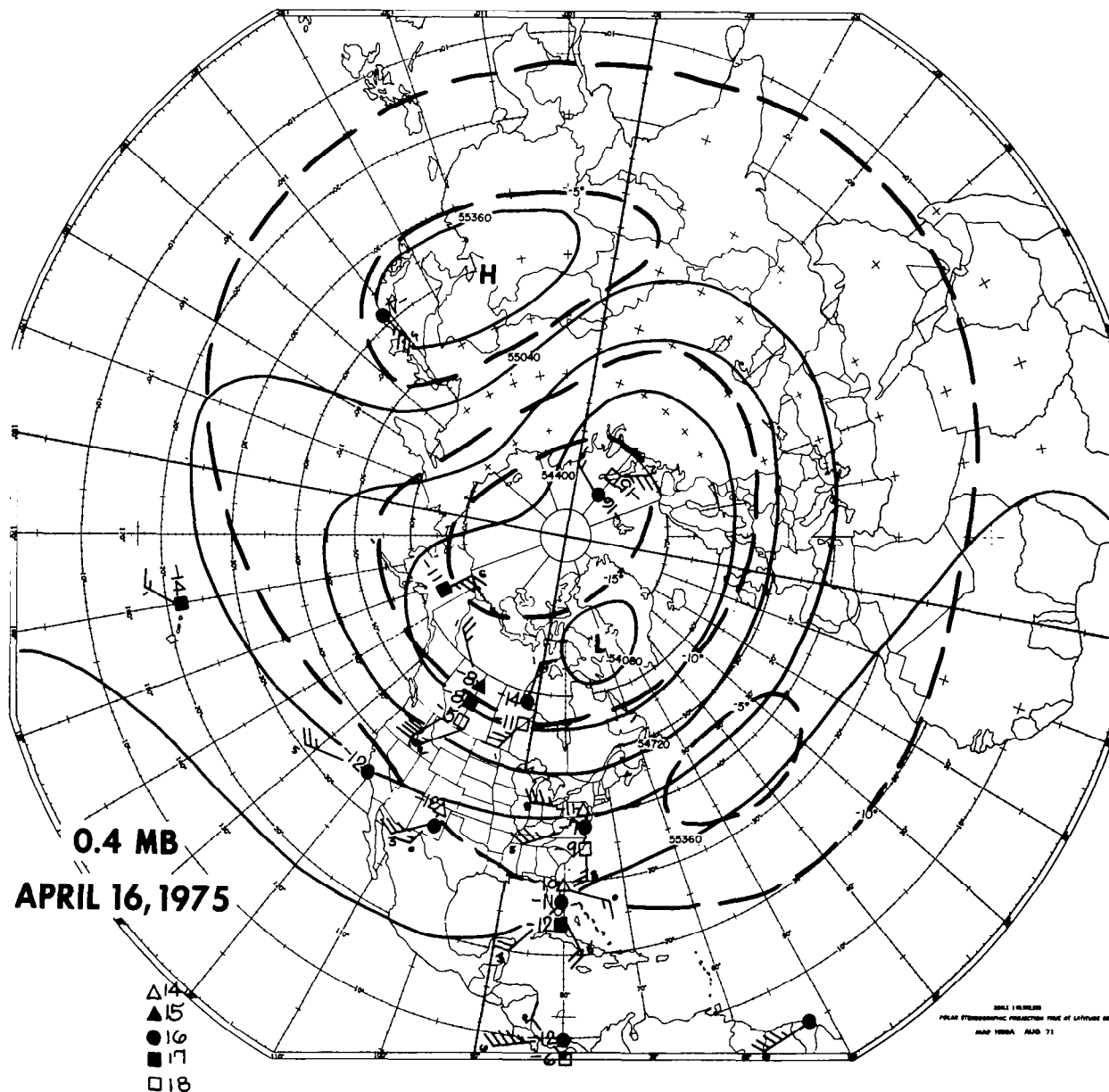


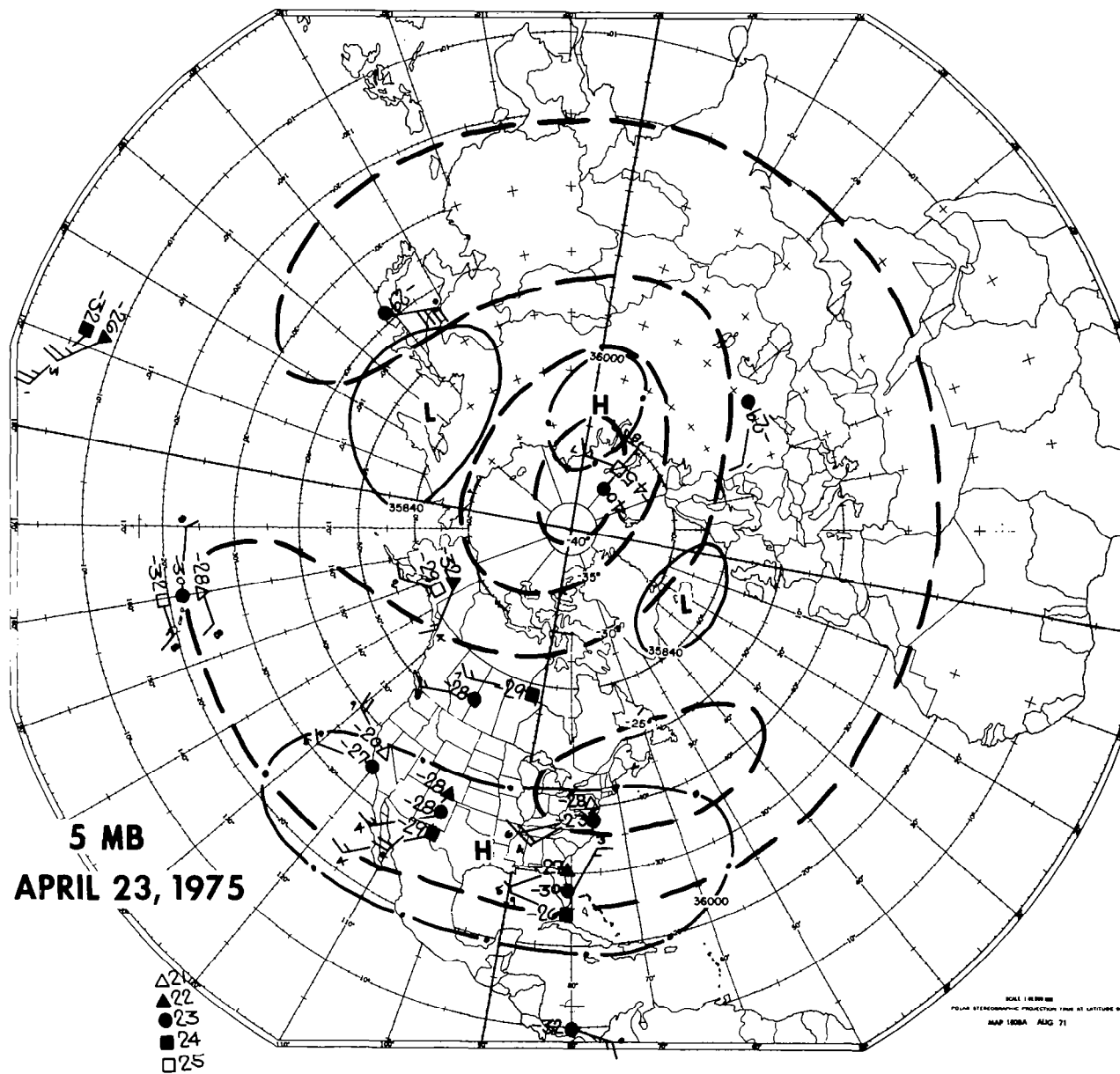




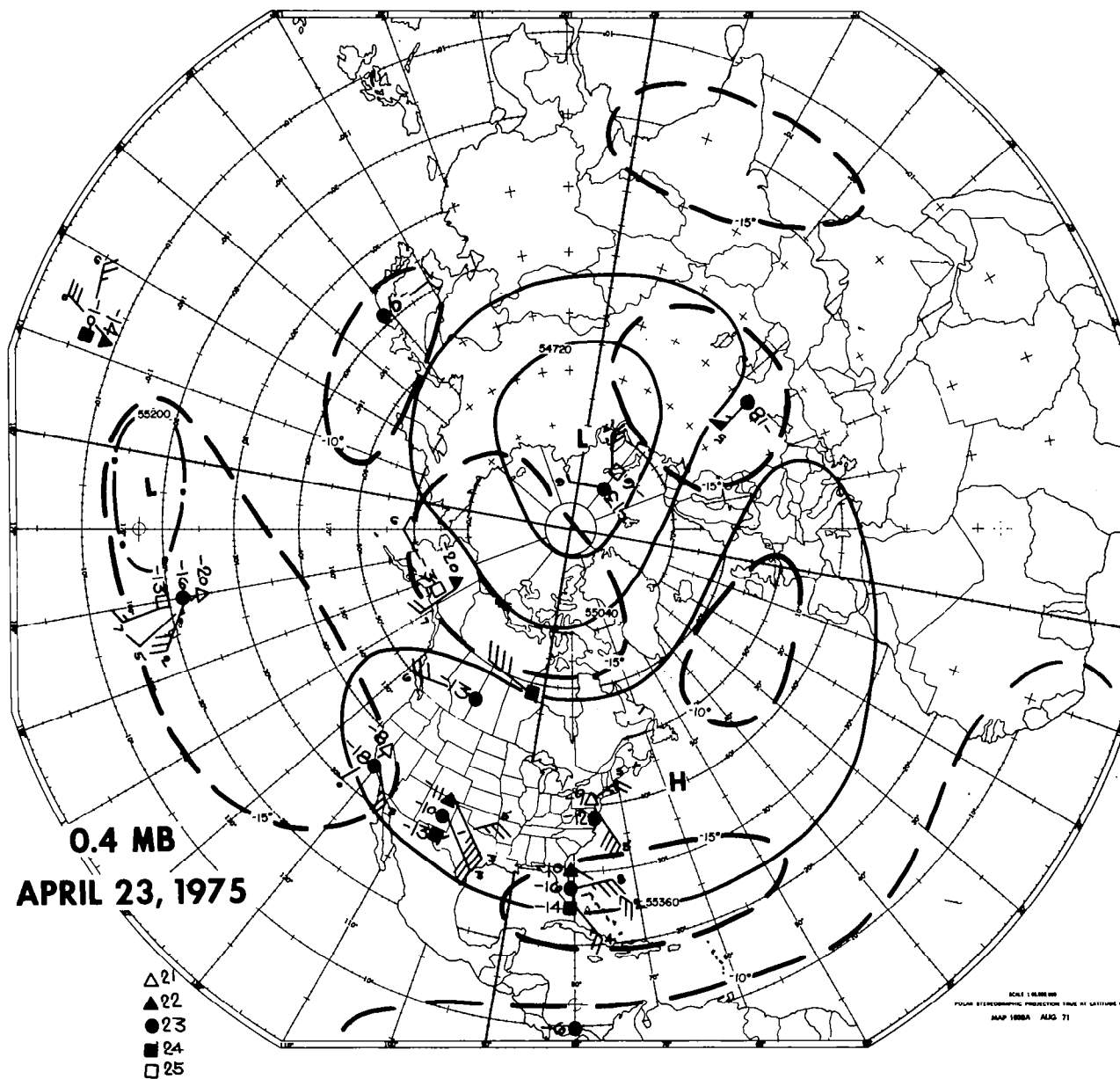


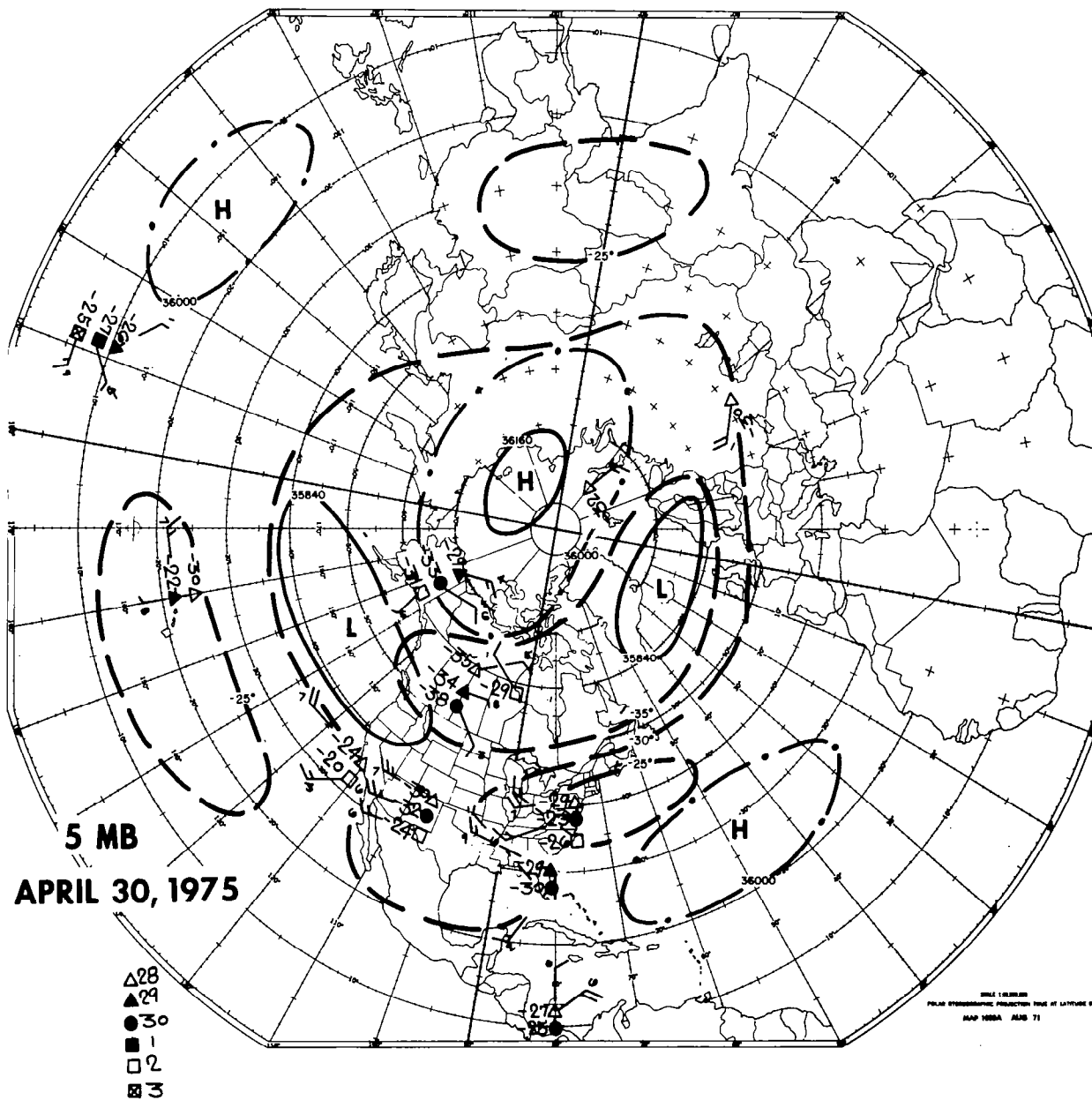




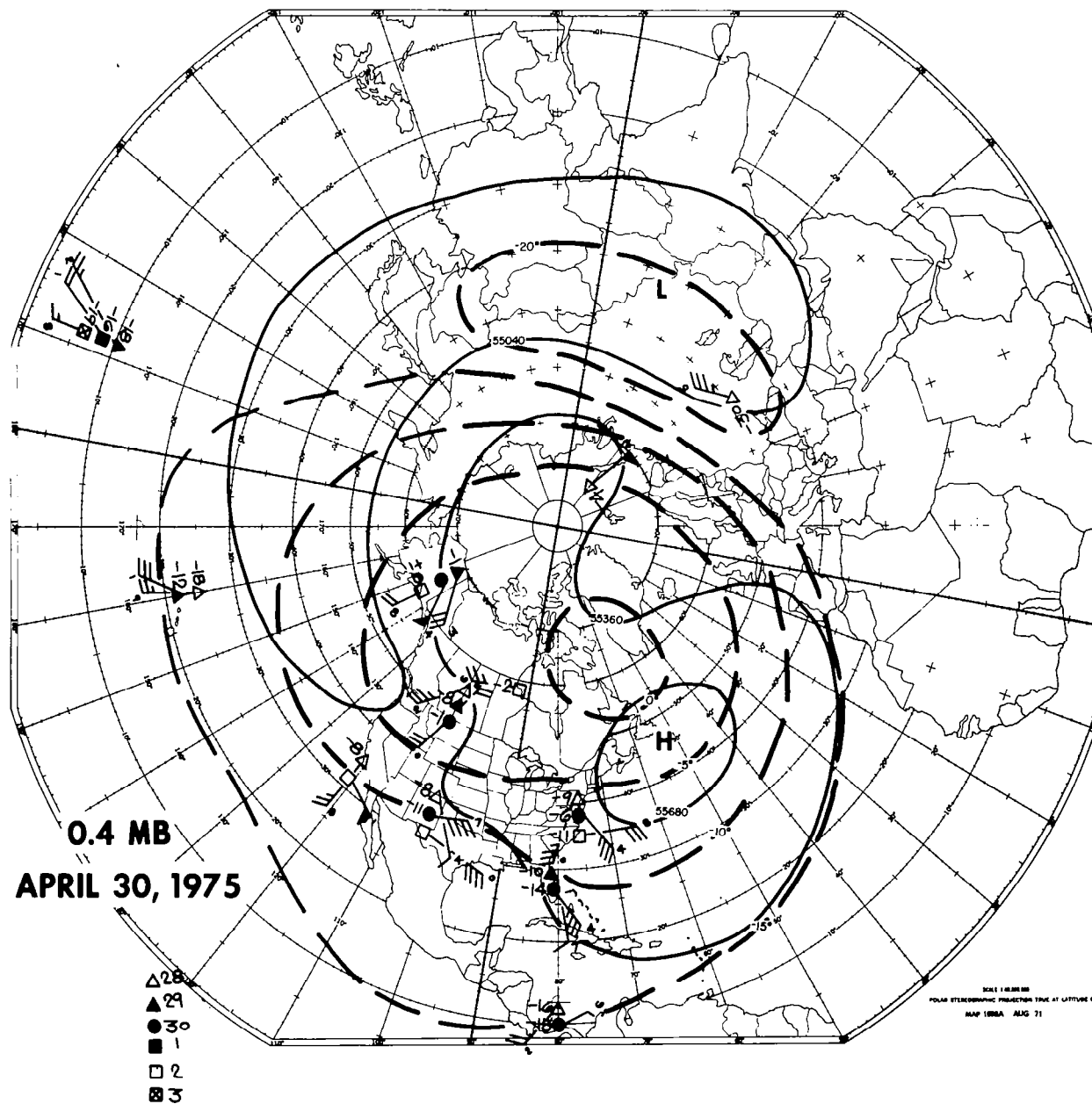




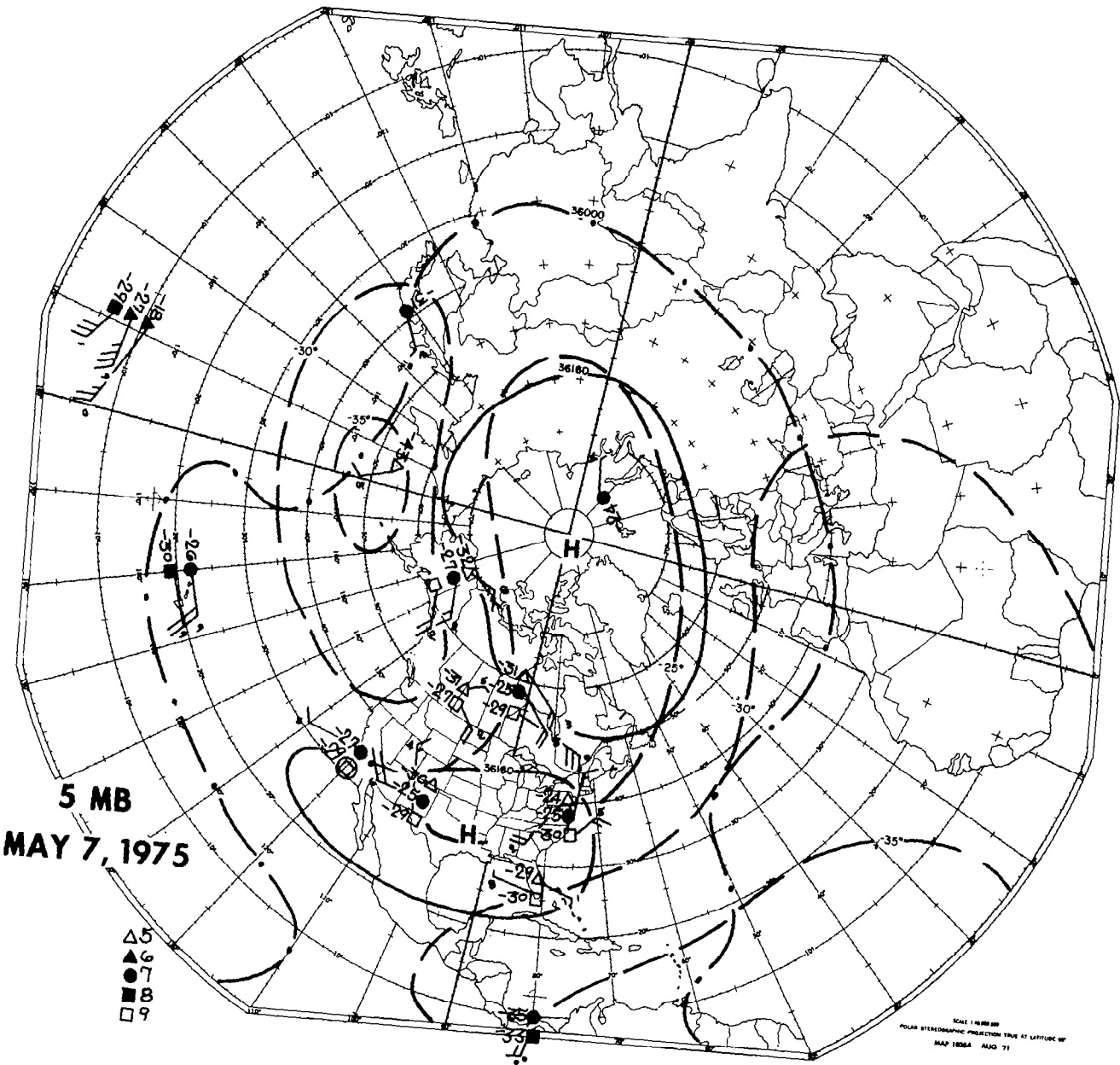




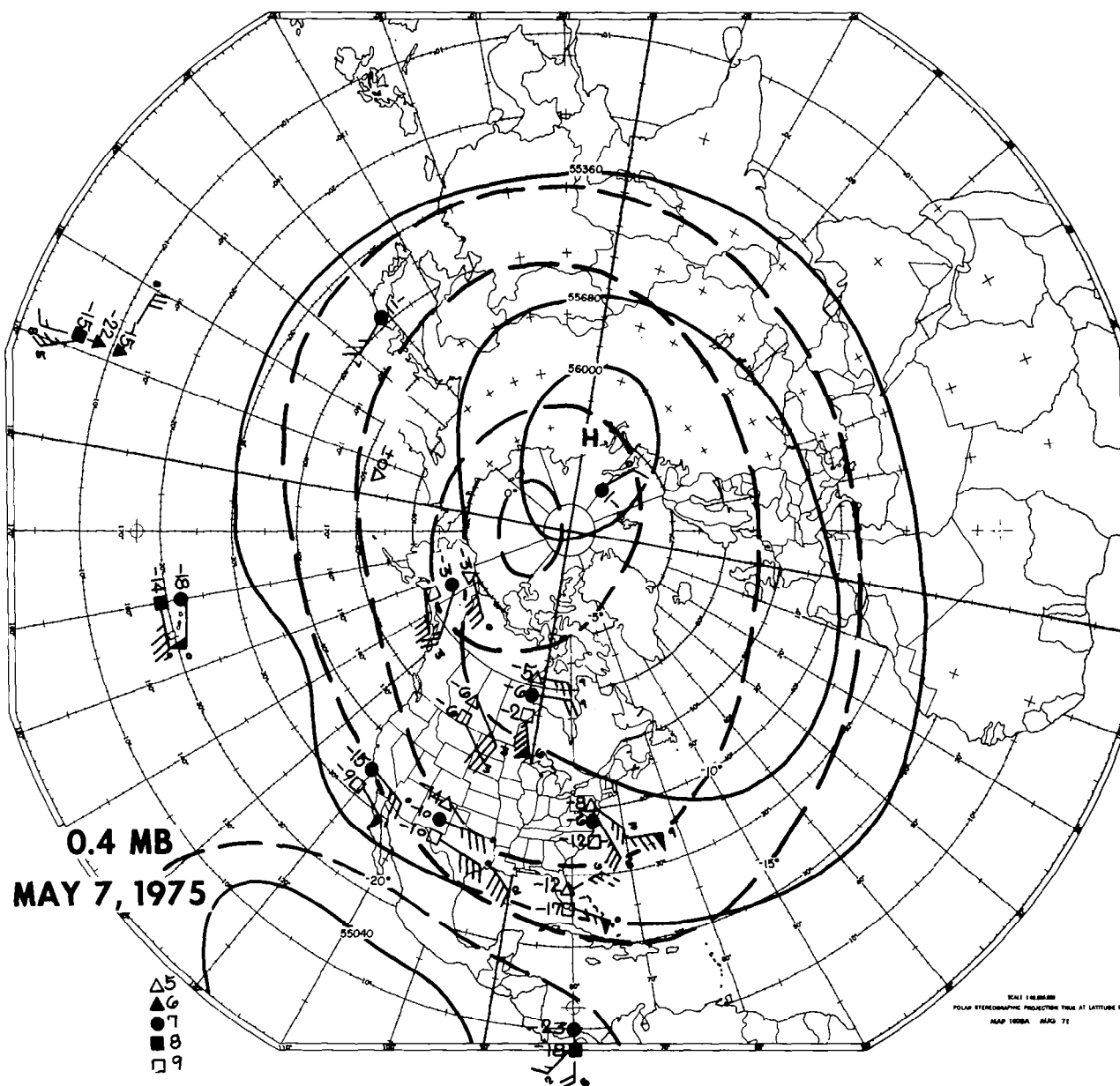


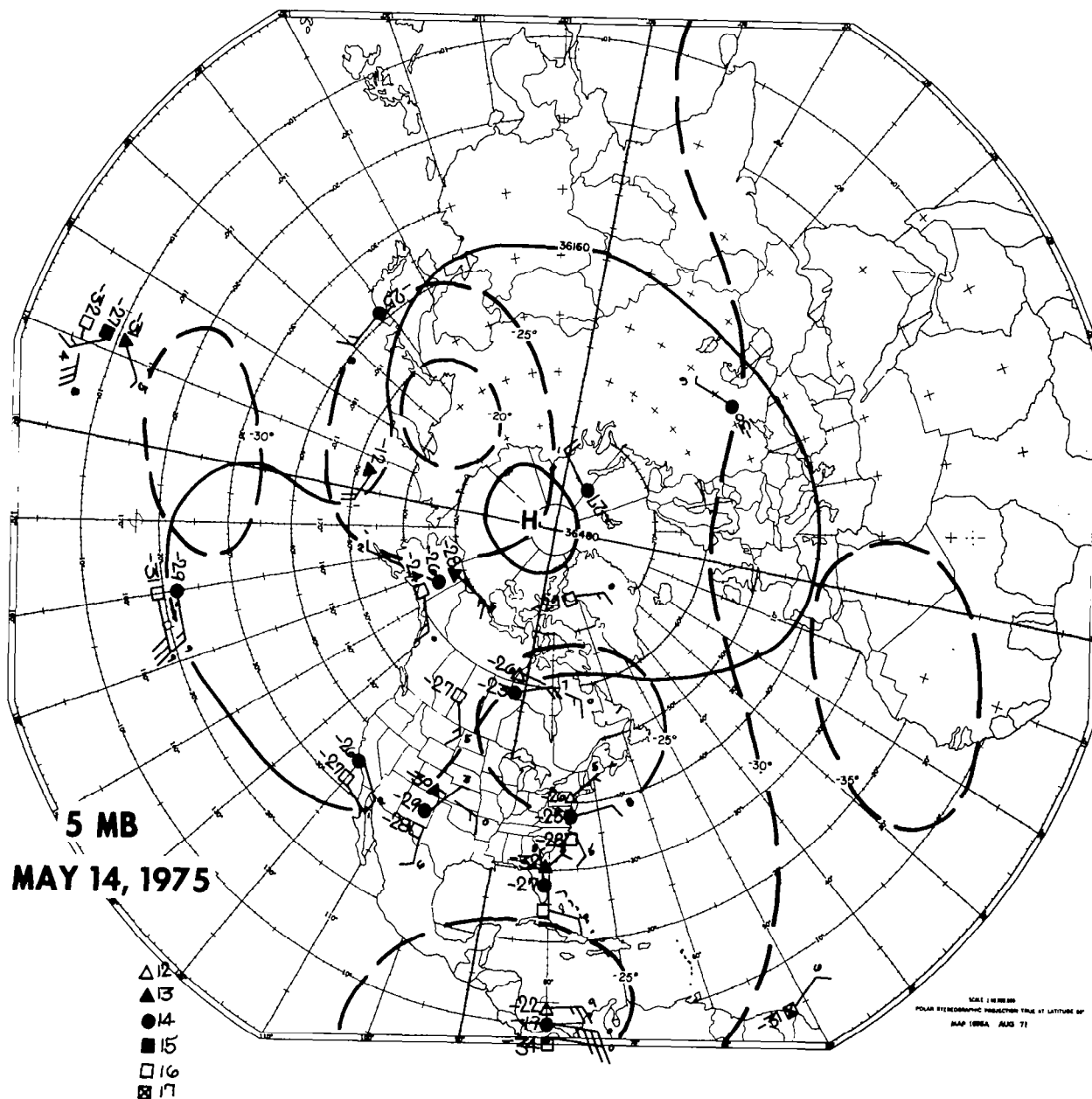


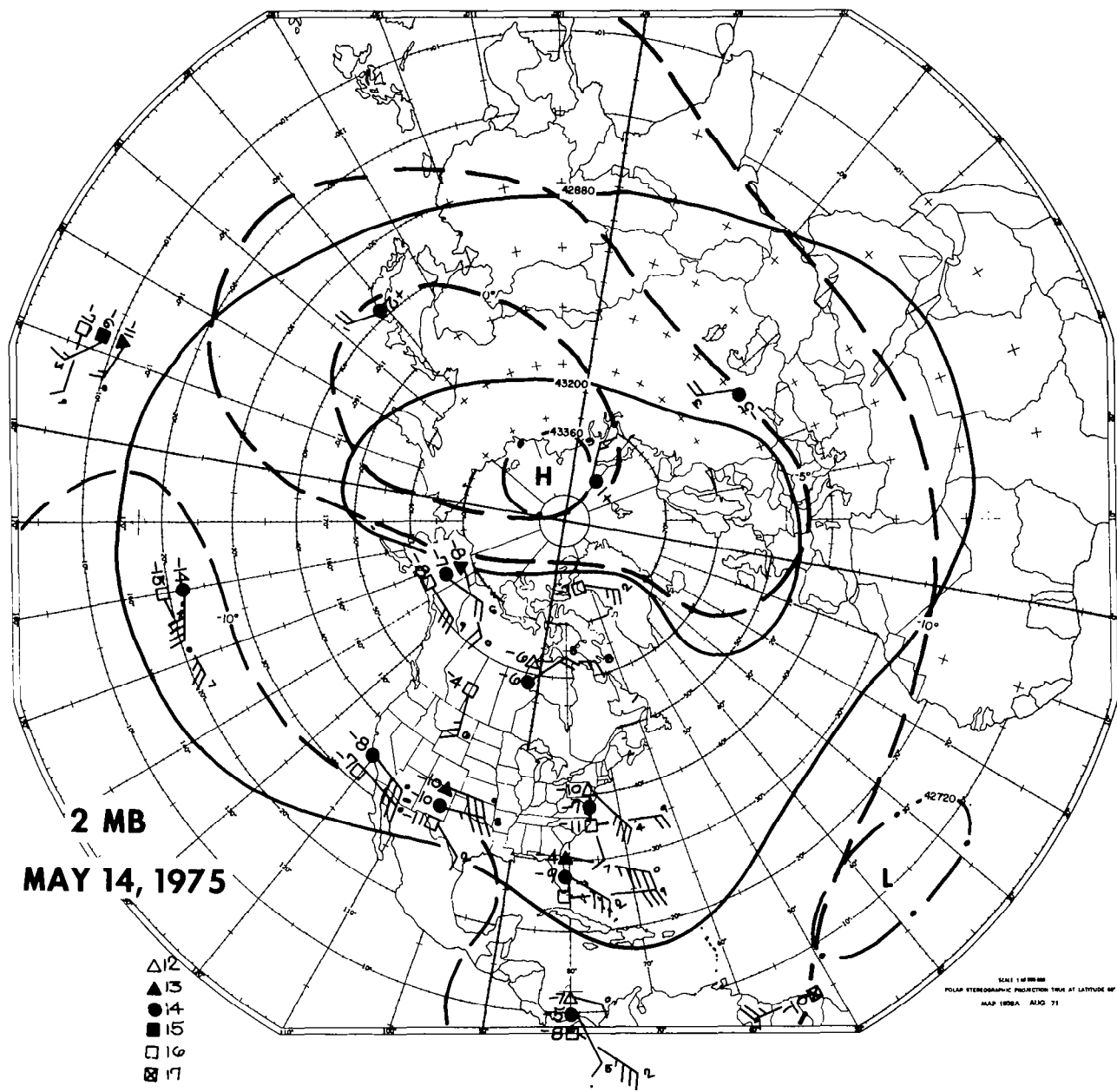


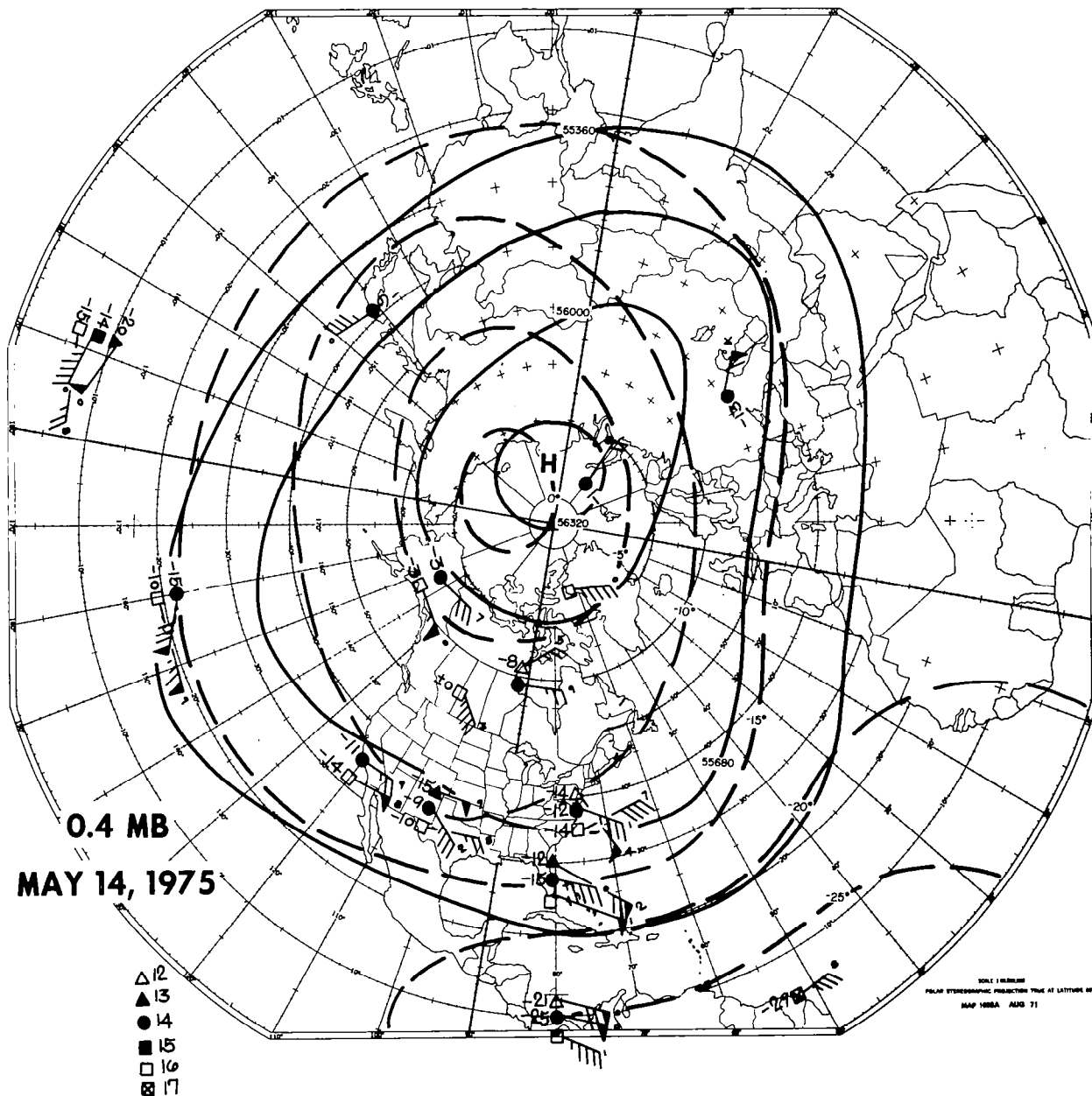








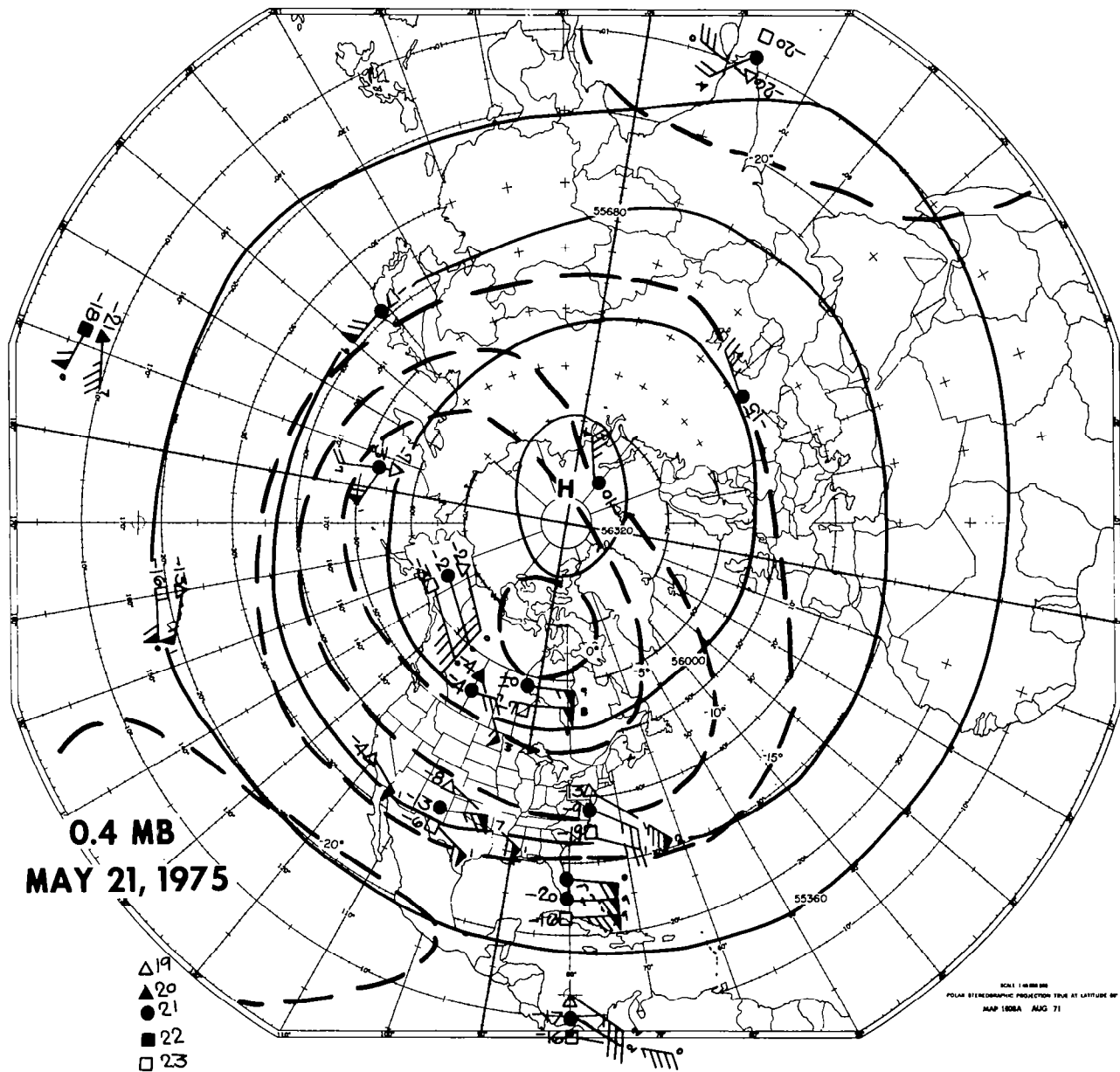




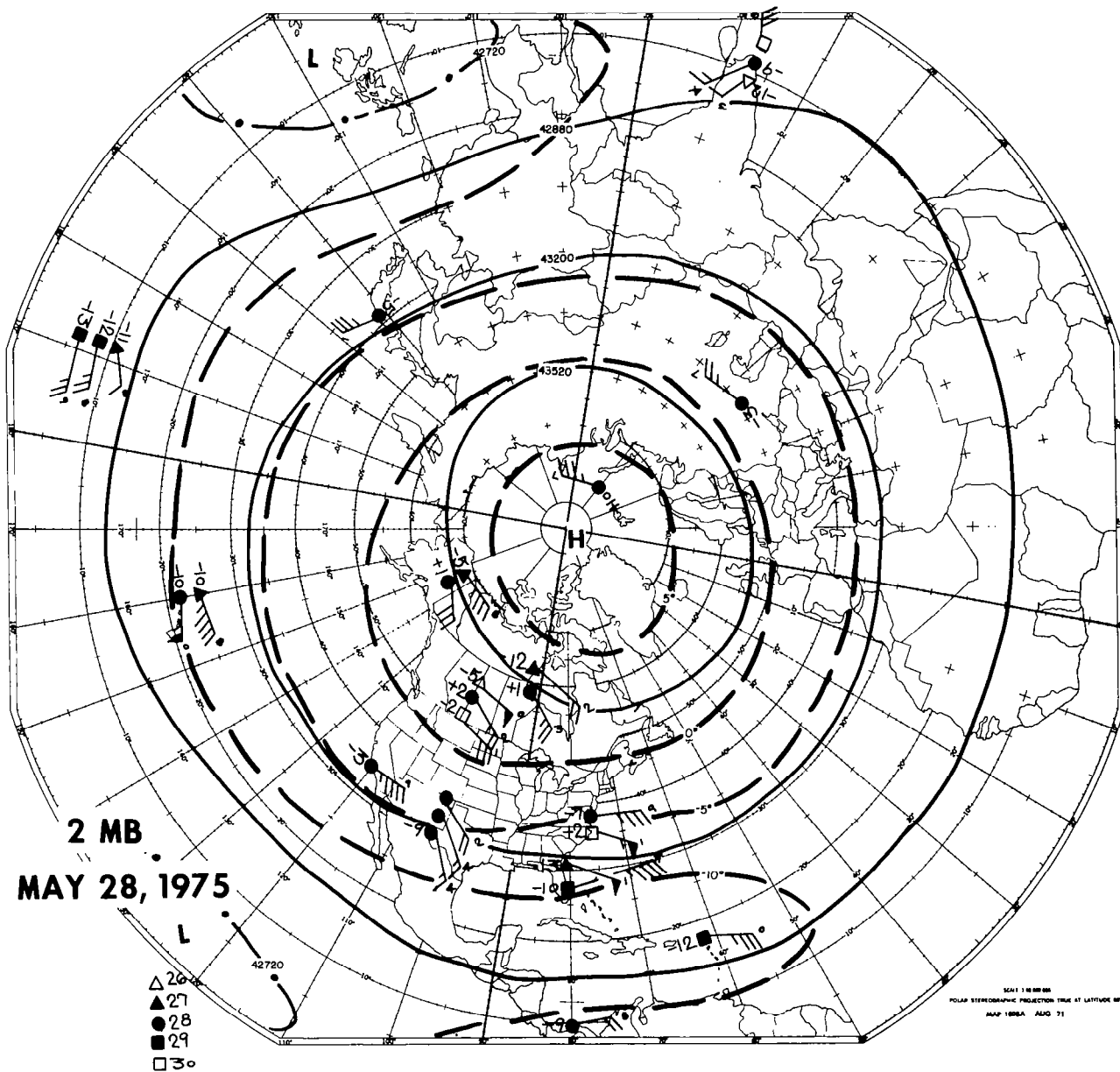
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POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 90°  
MAP 1008A AUG 71

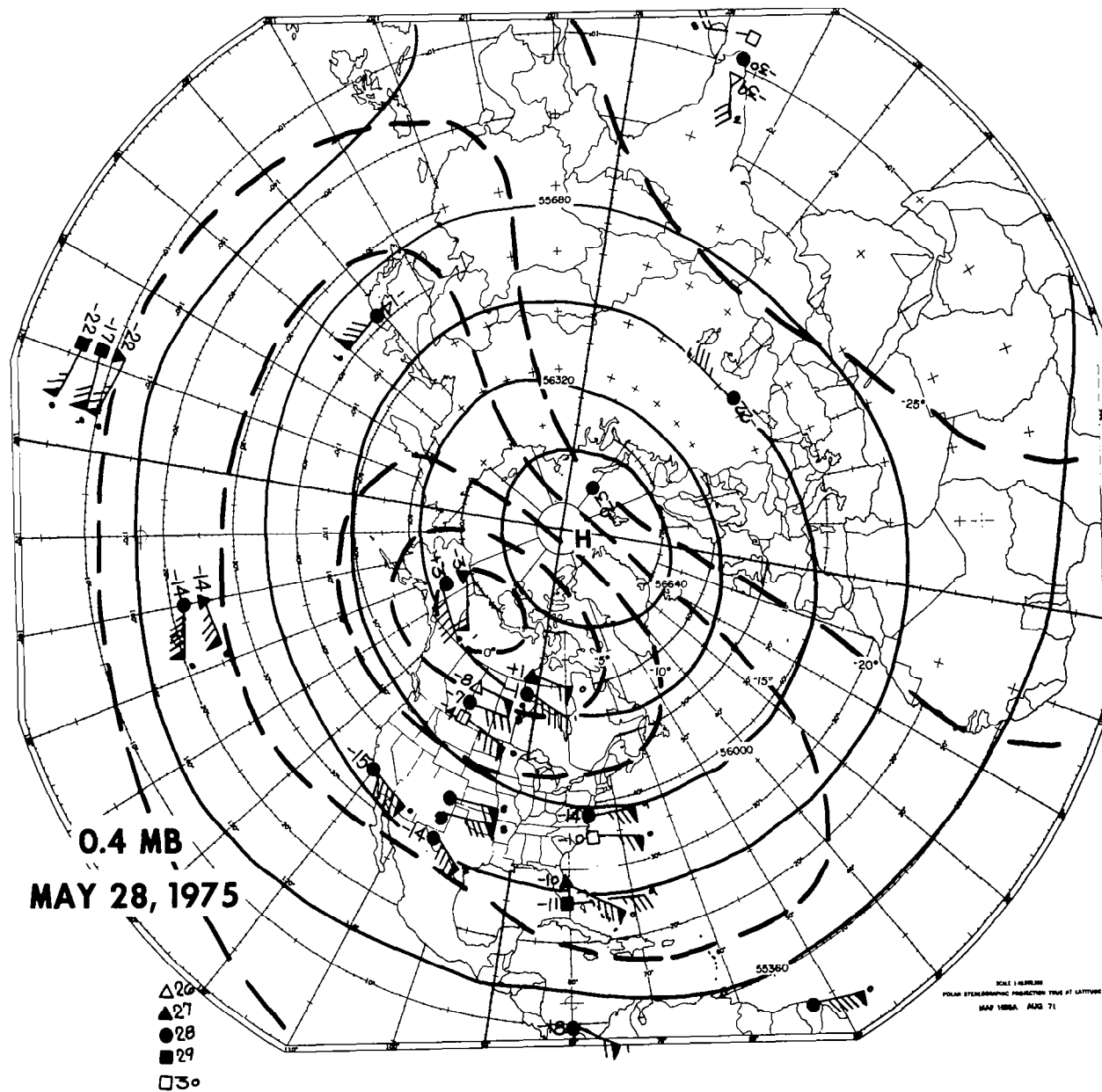


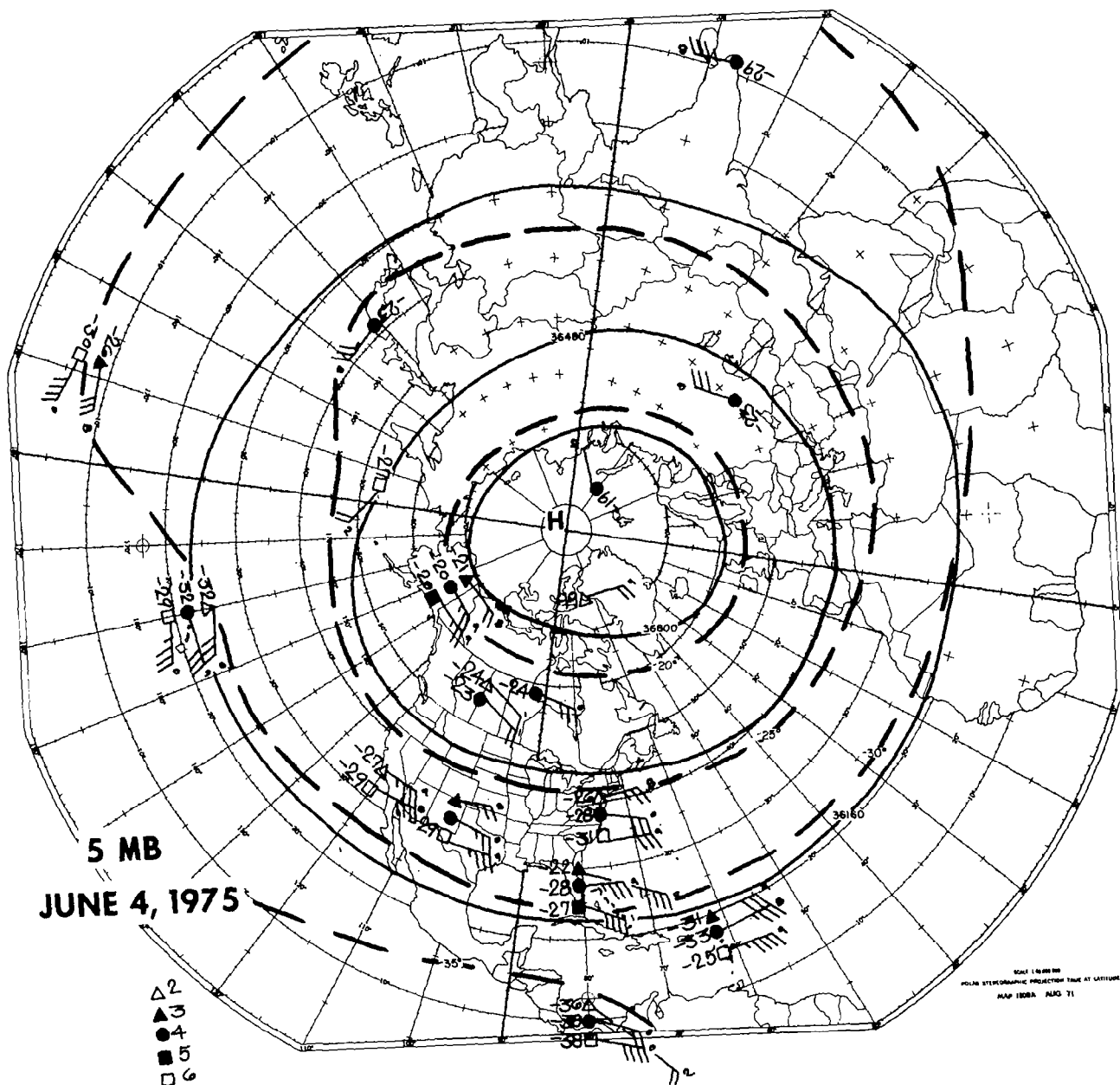


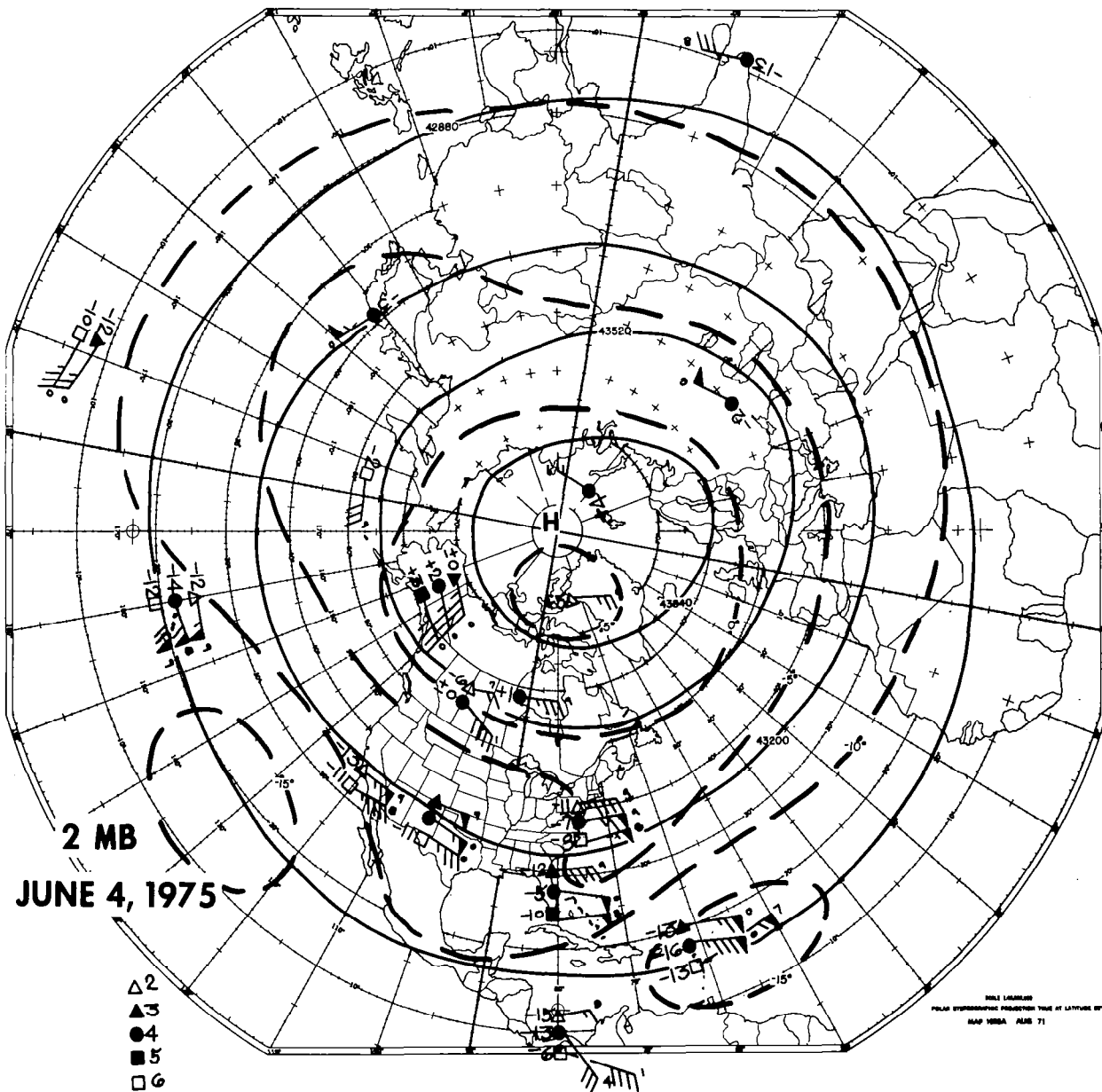


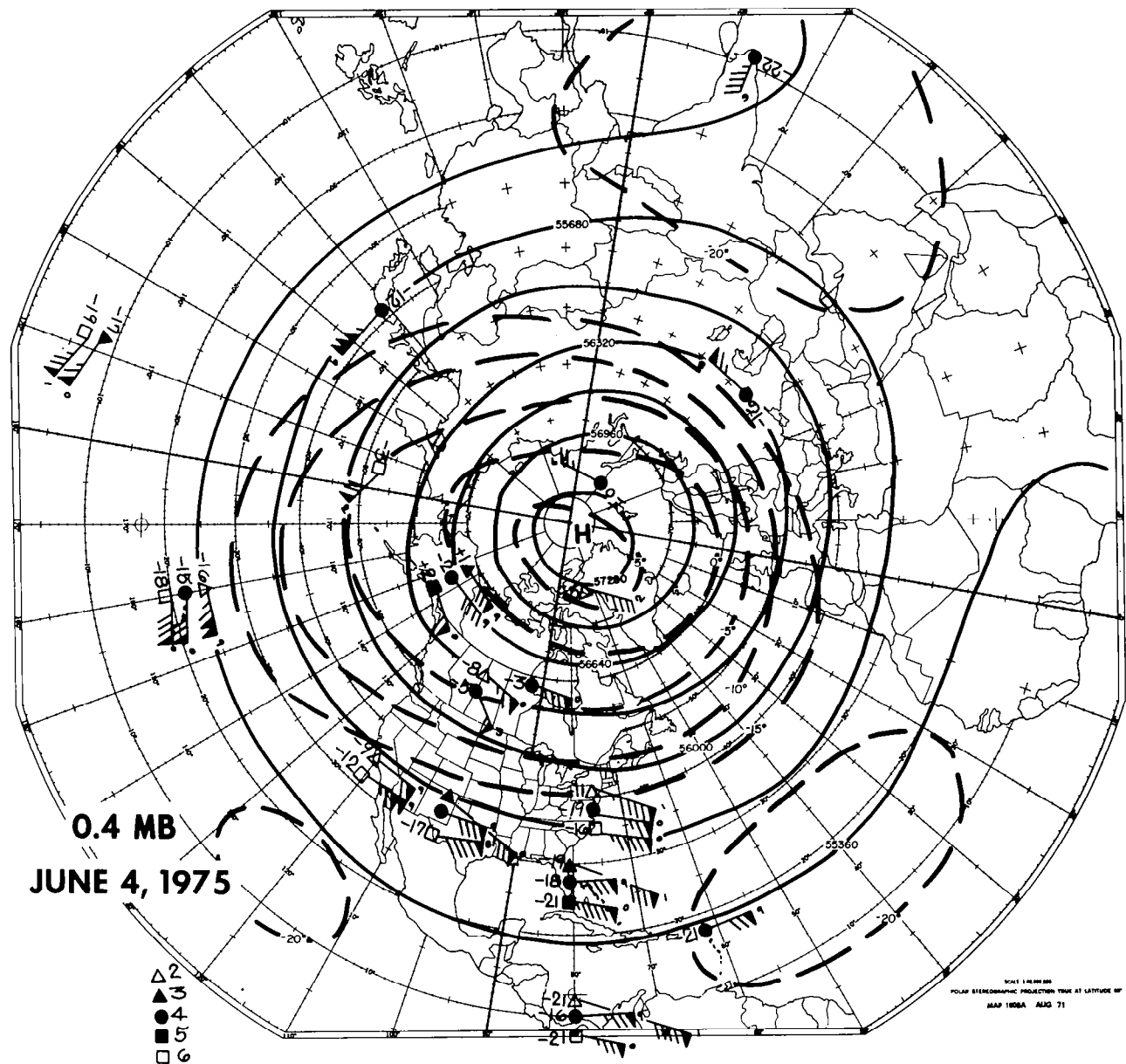


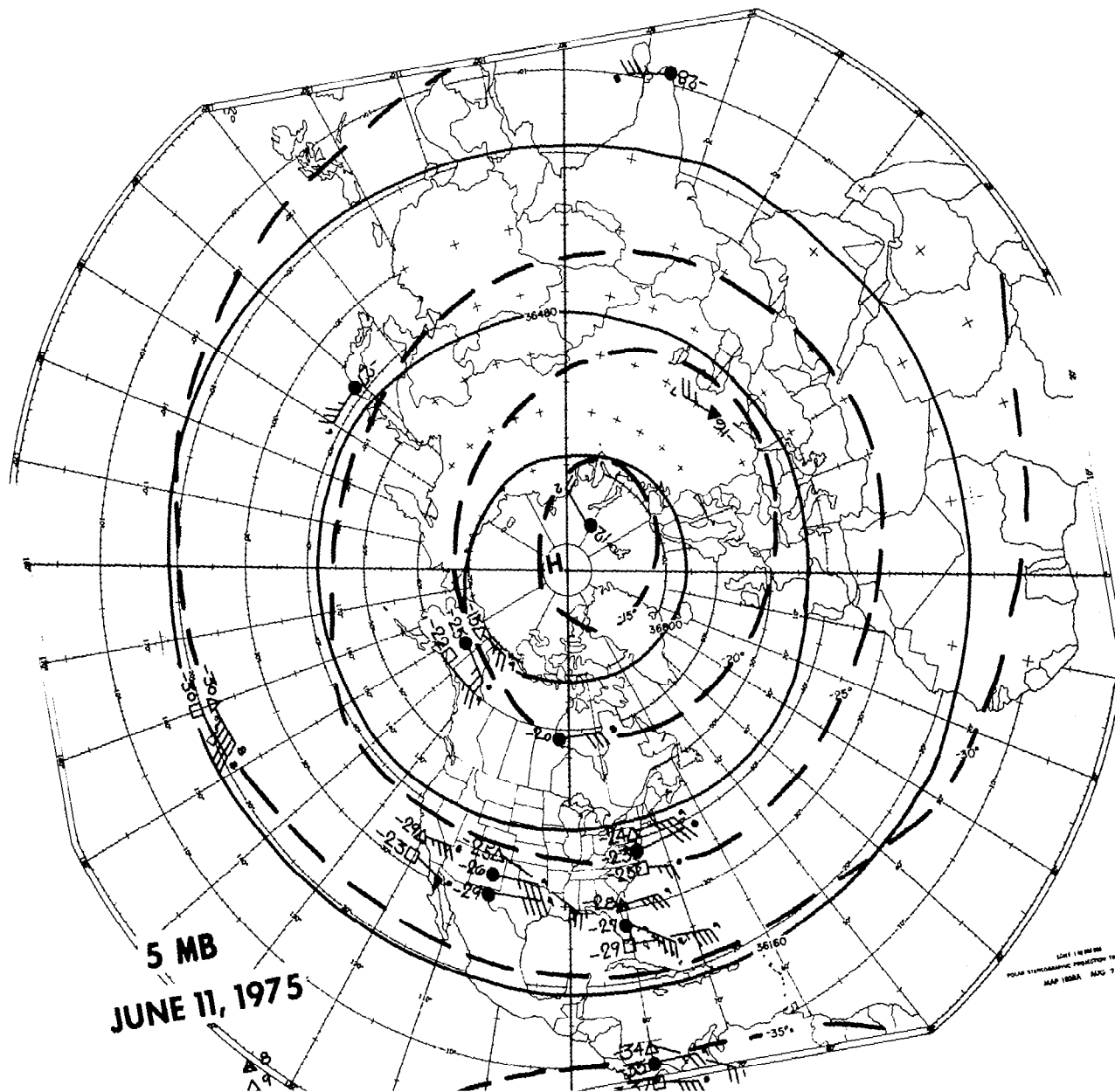










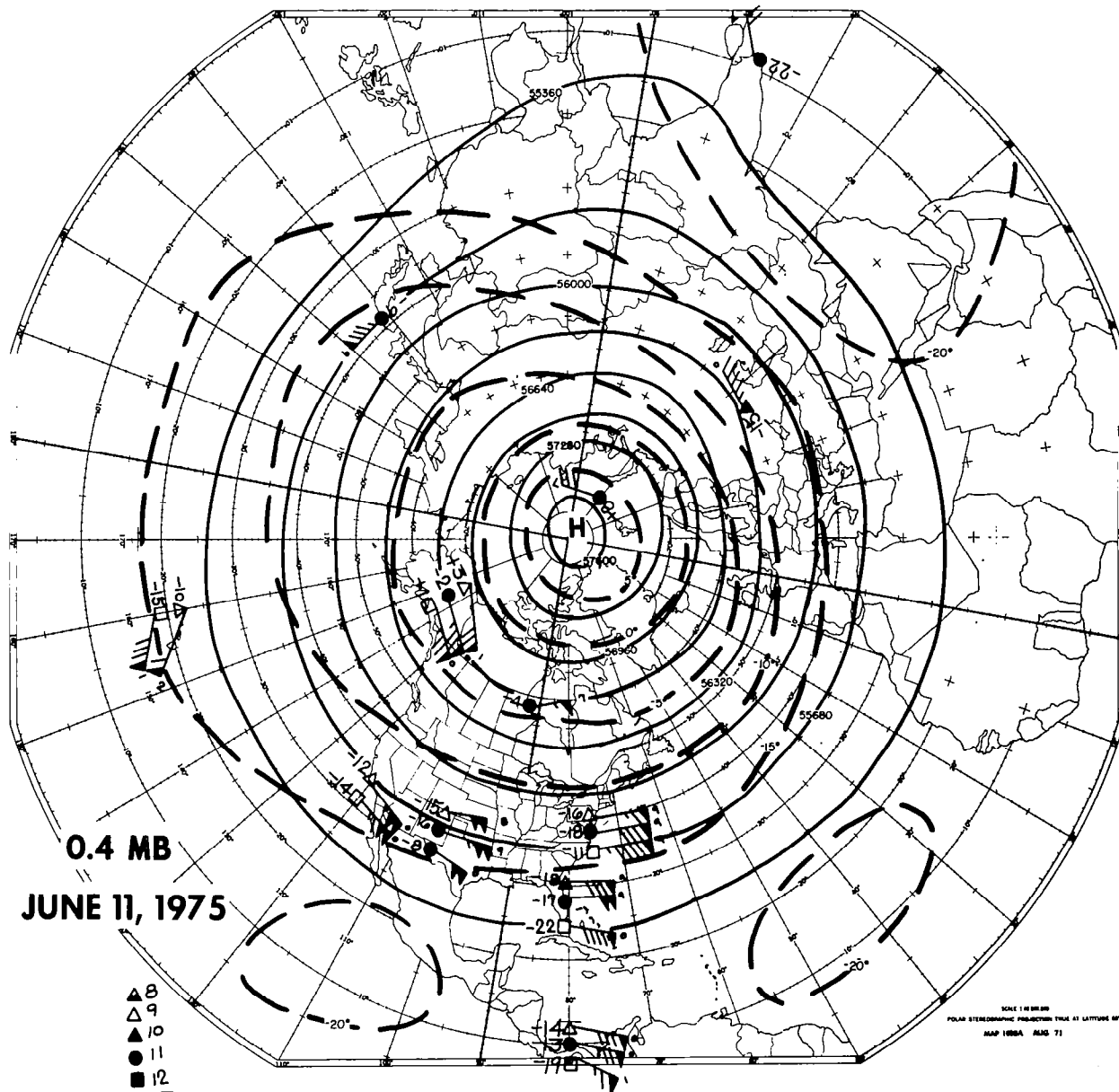


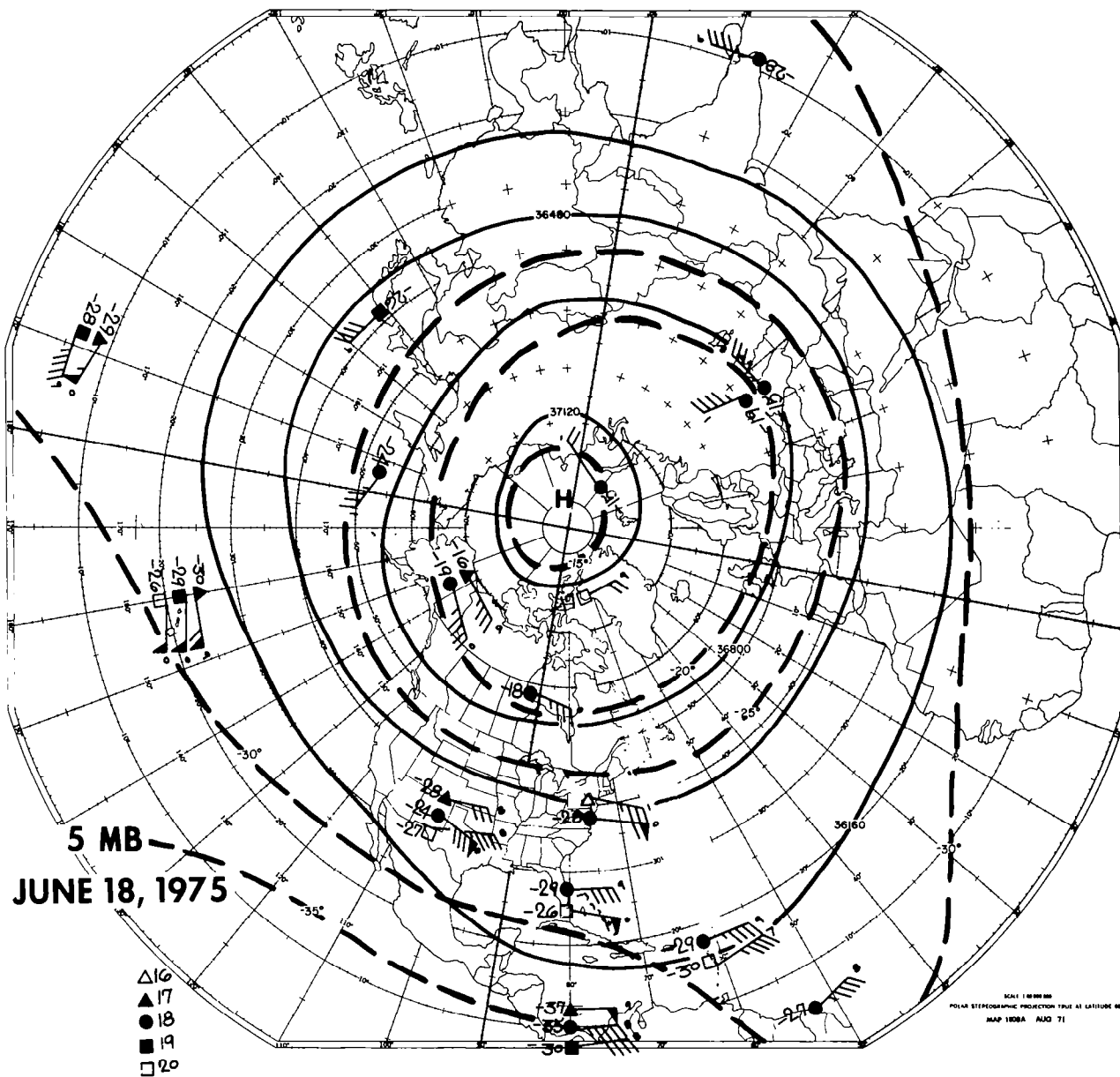
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**JUNE 11, 1975**

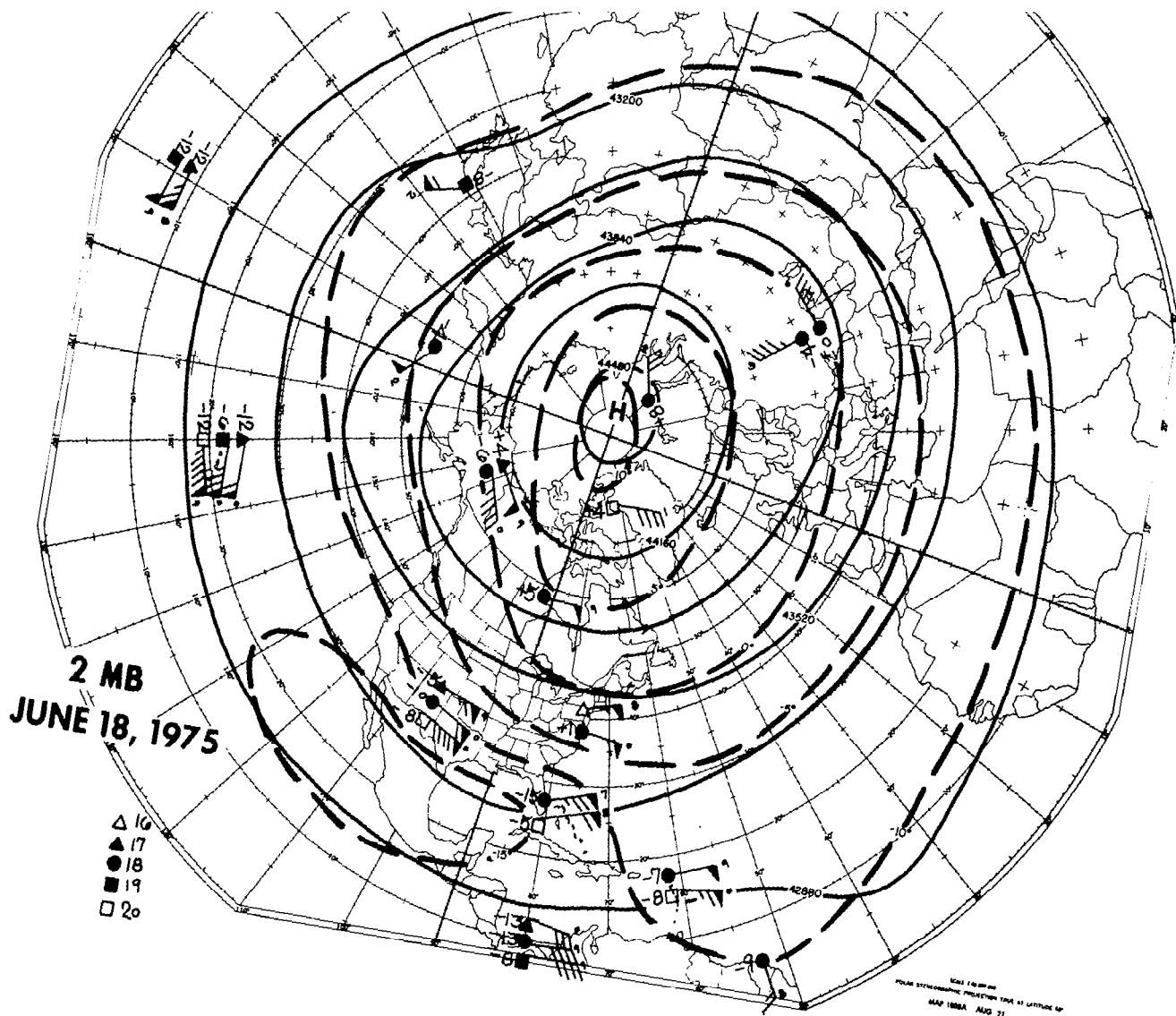
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 POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 80°N  
 MAP 1008A AUG 75

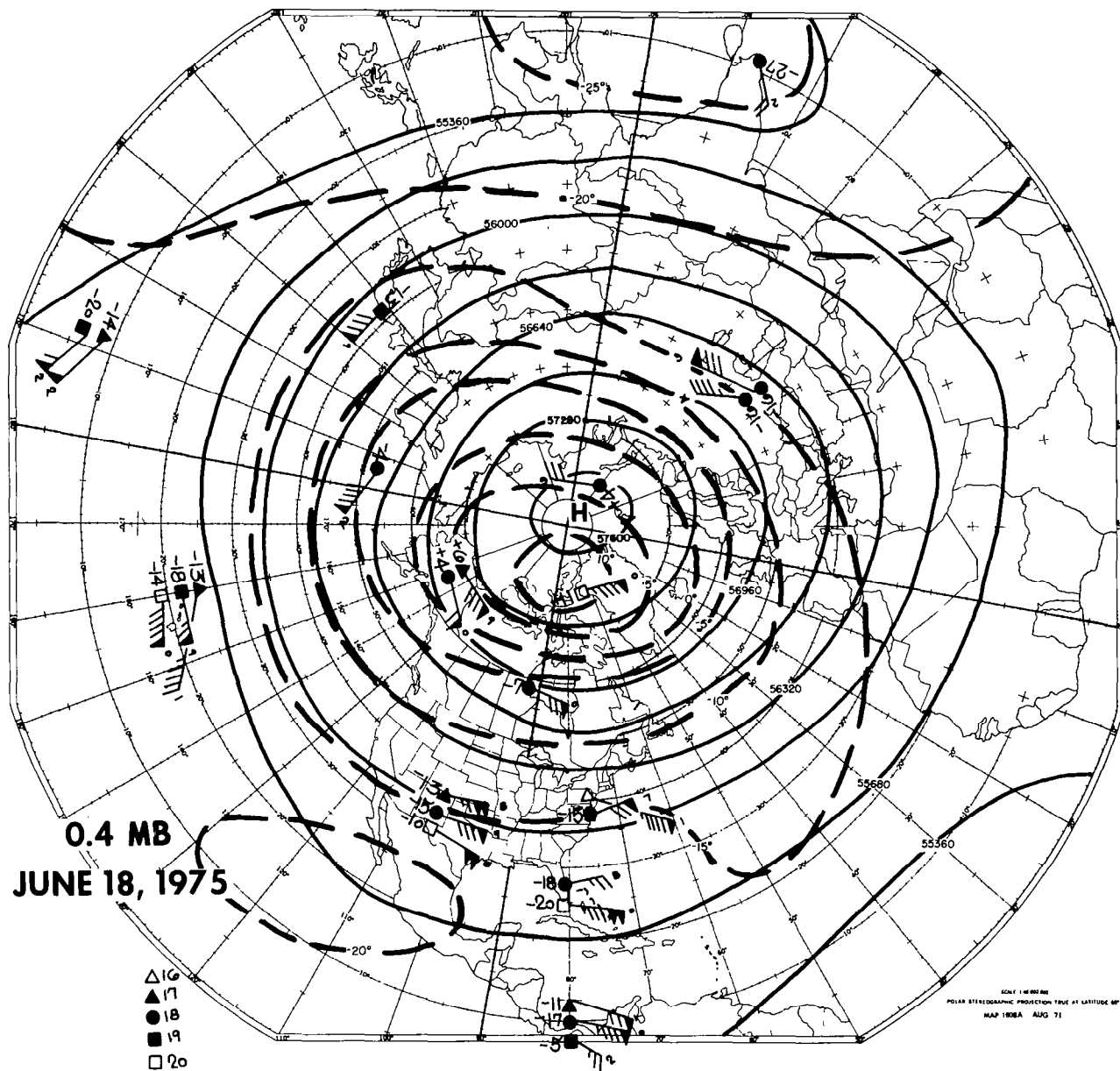


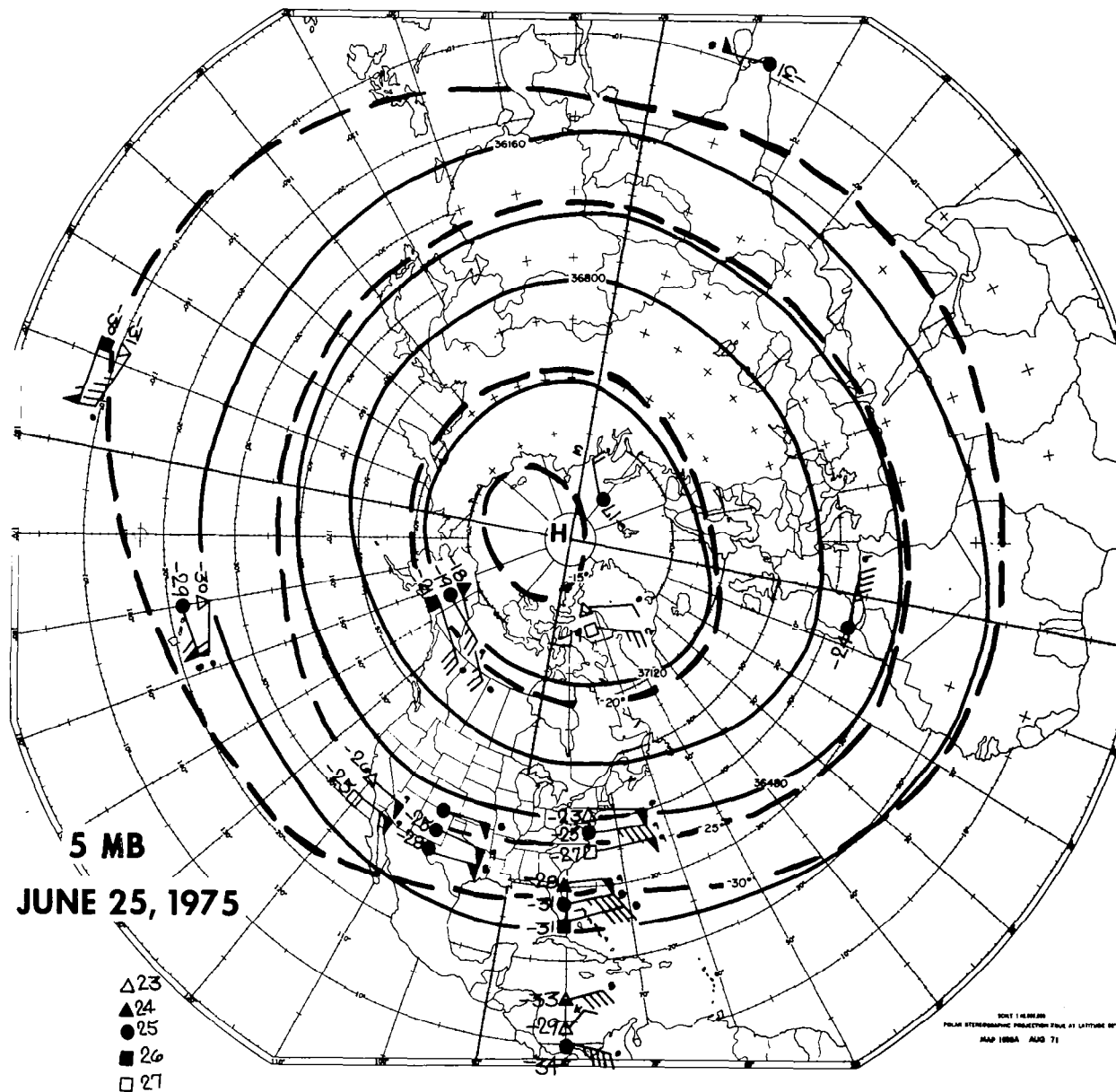


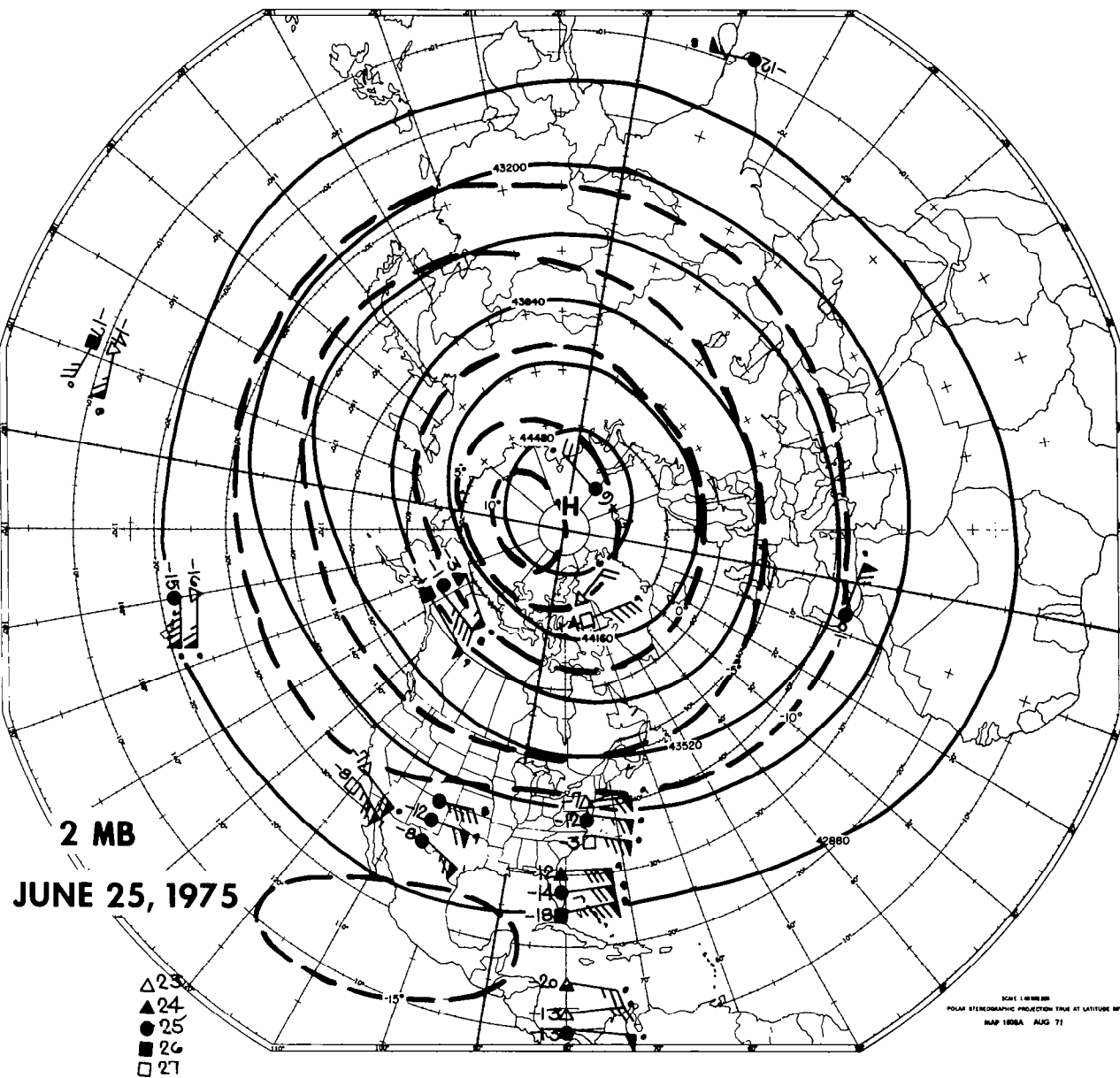


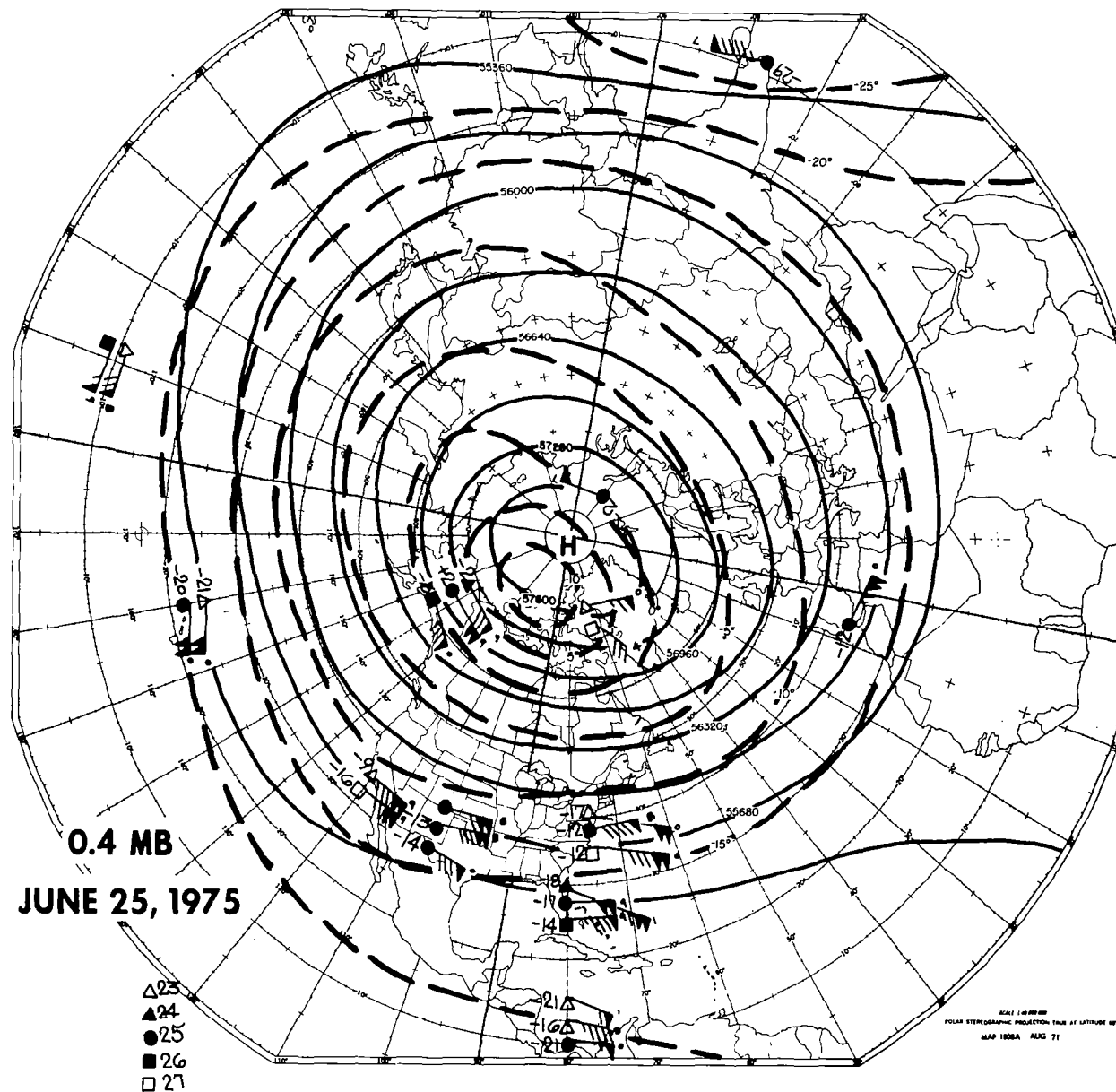




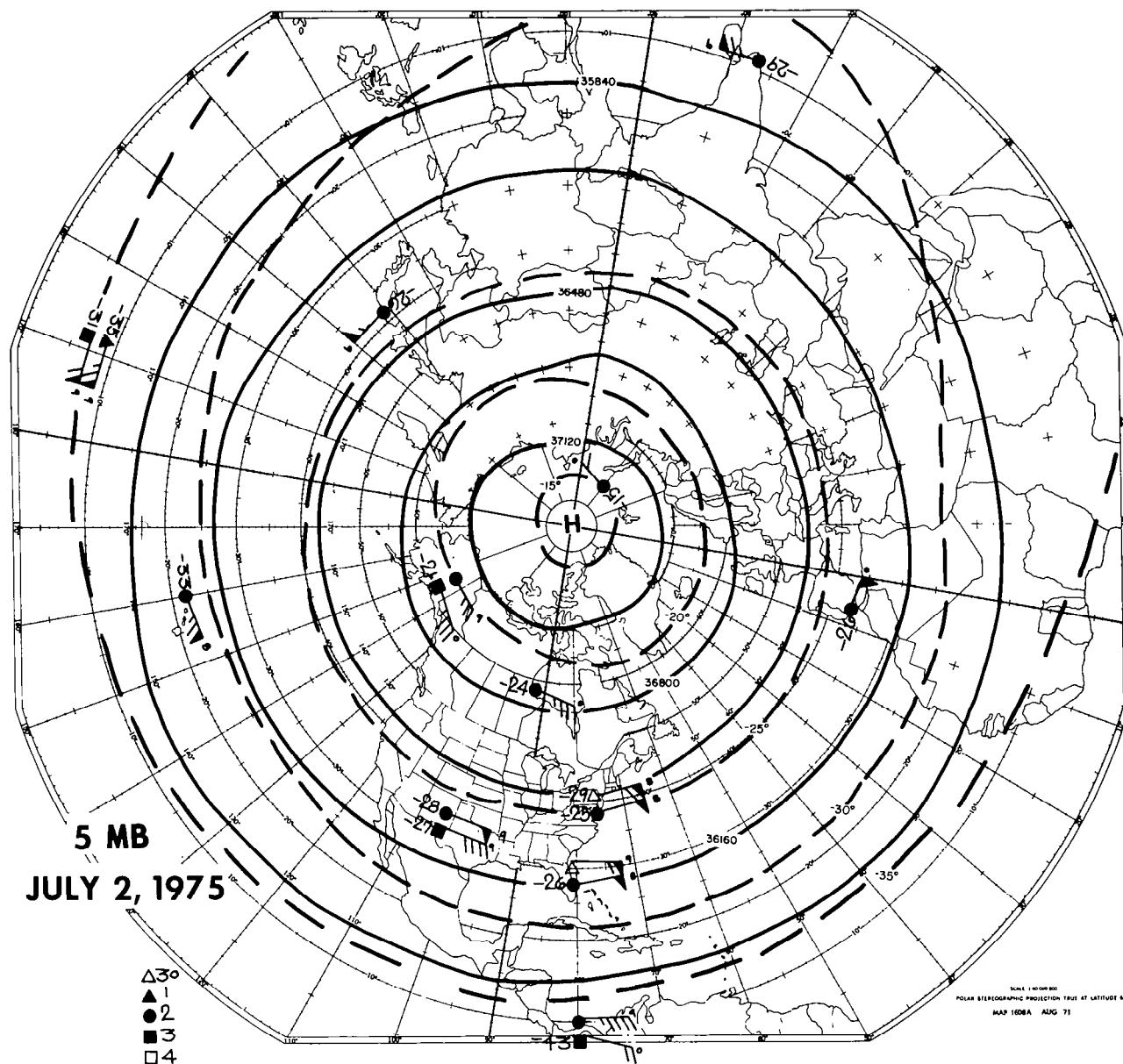


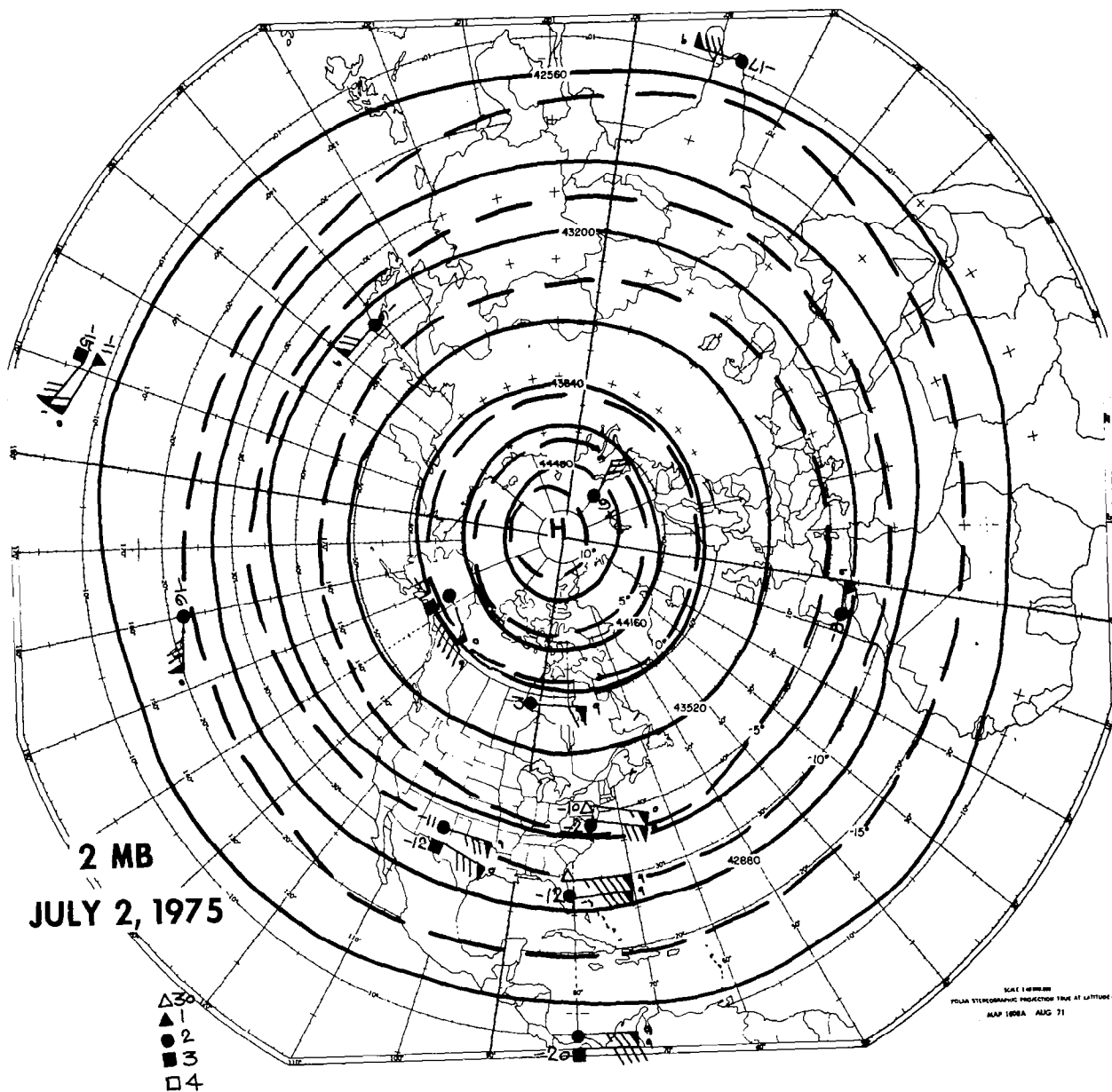


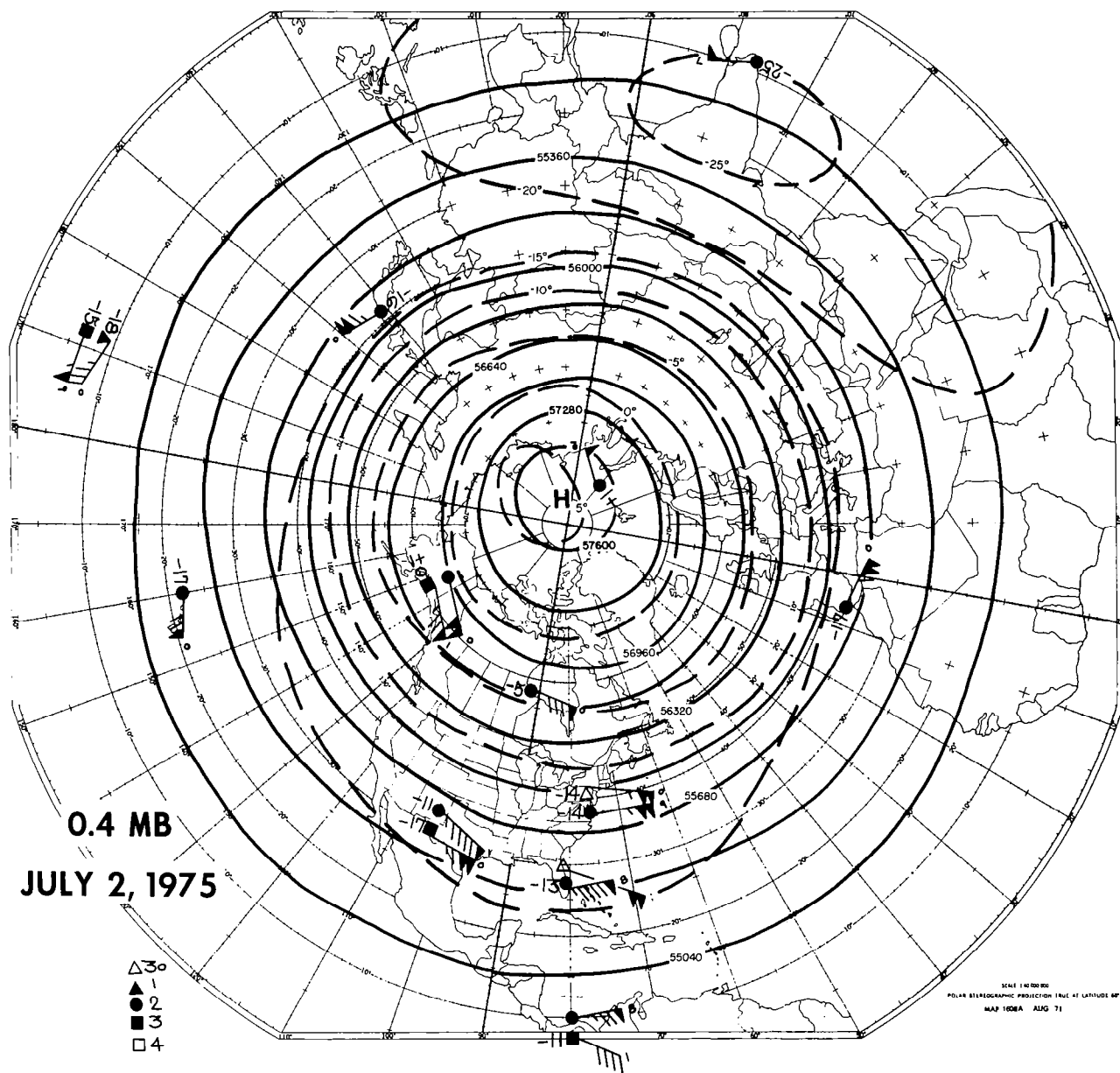


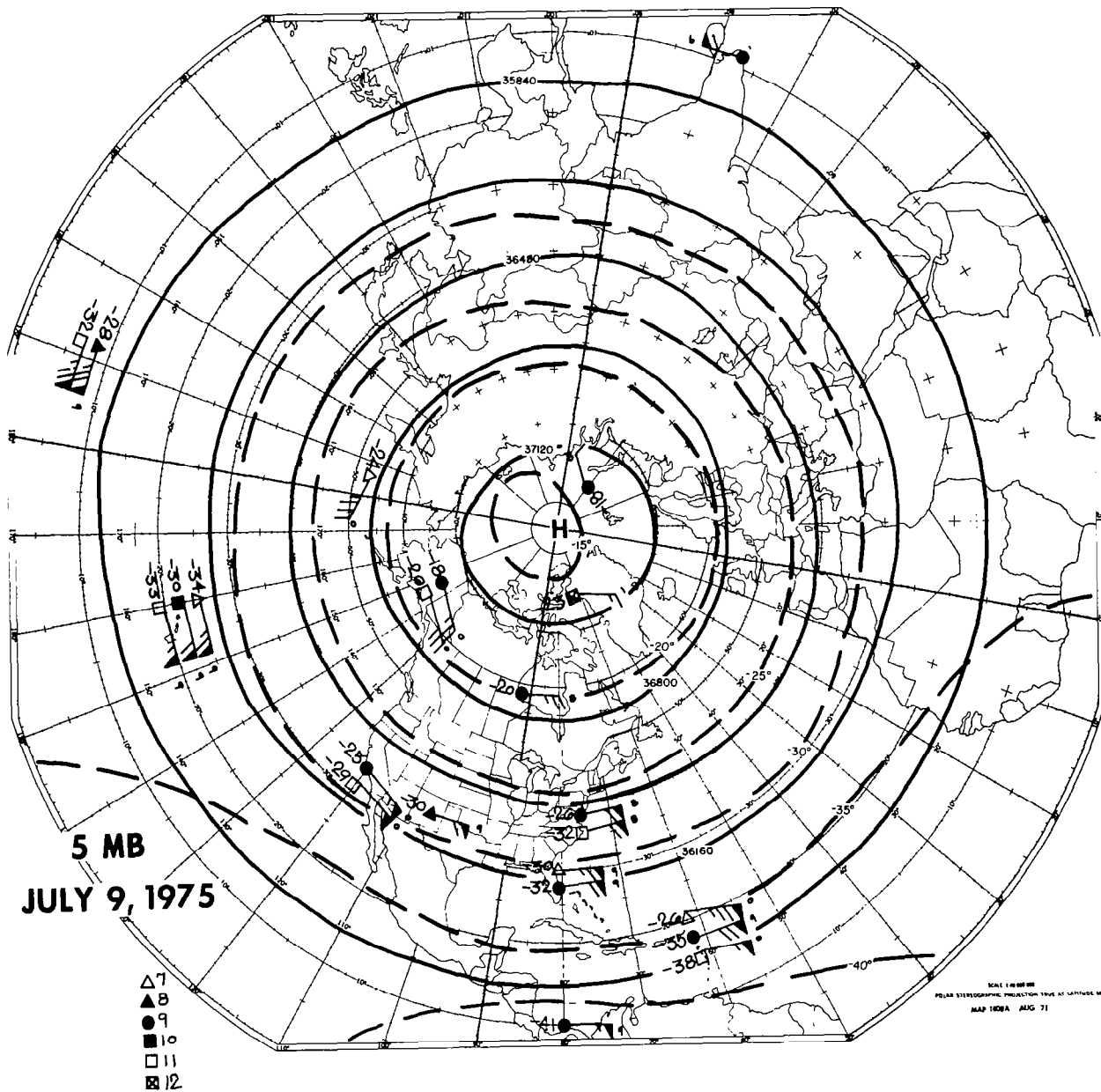


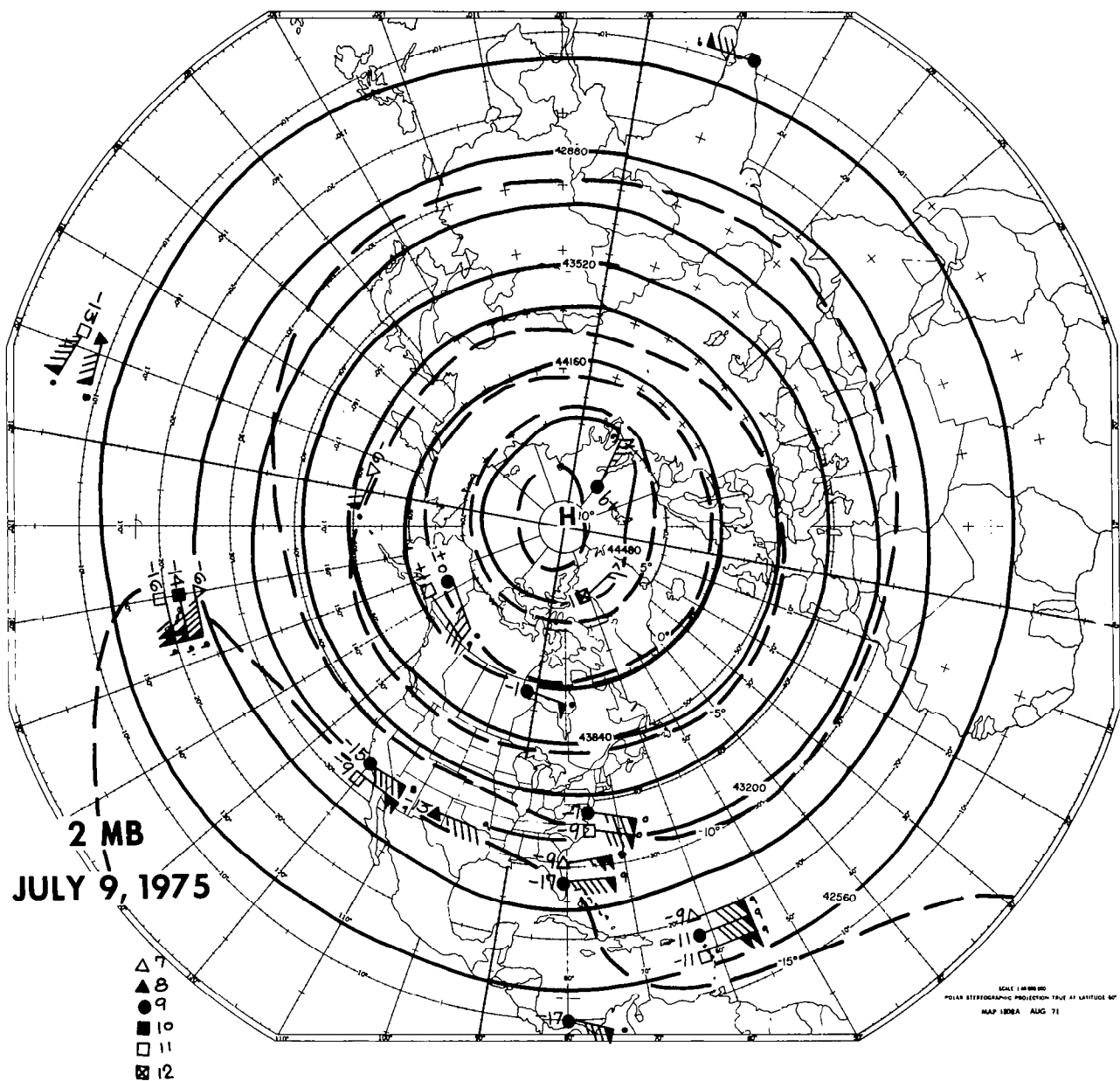


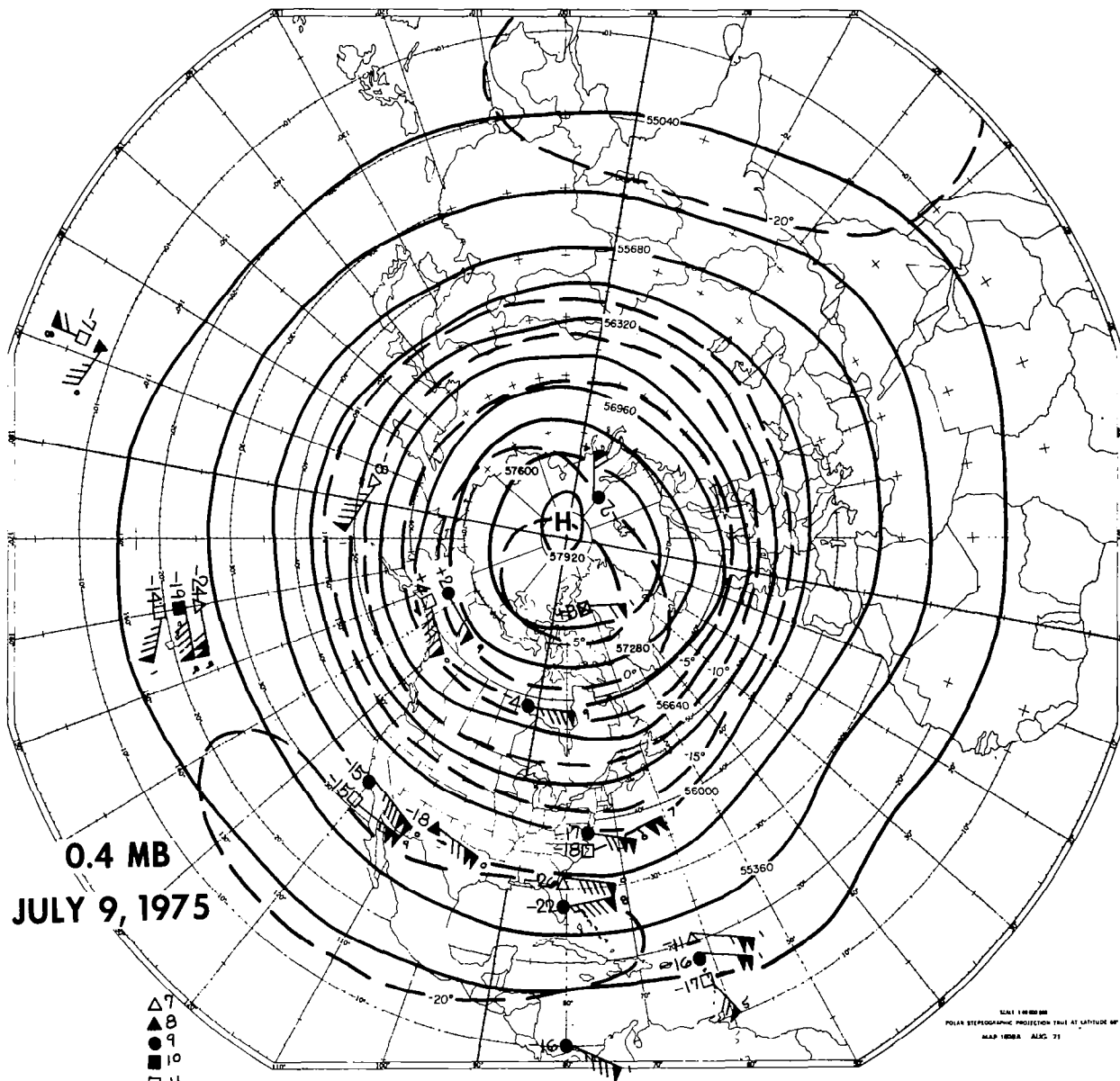


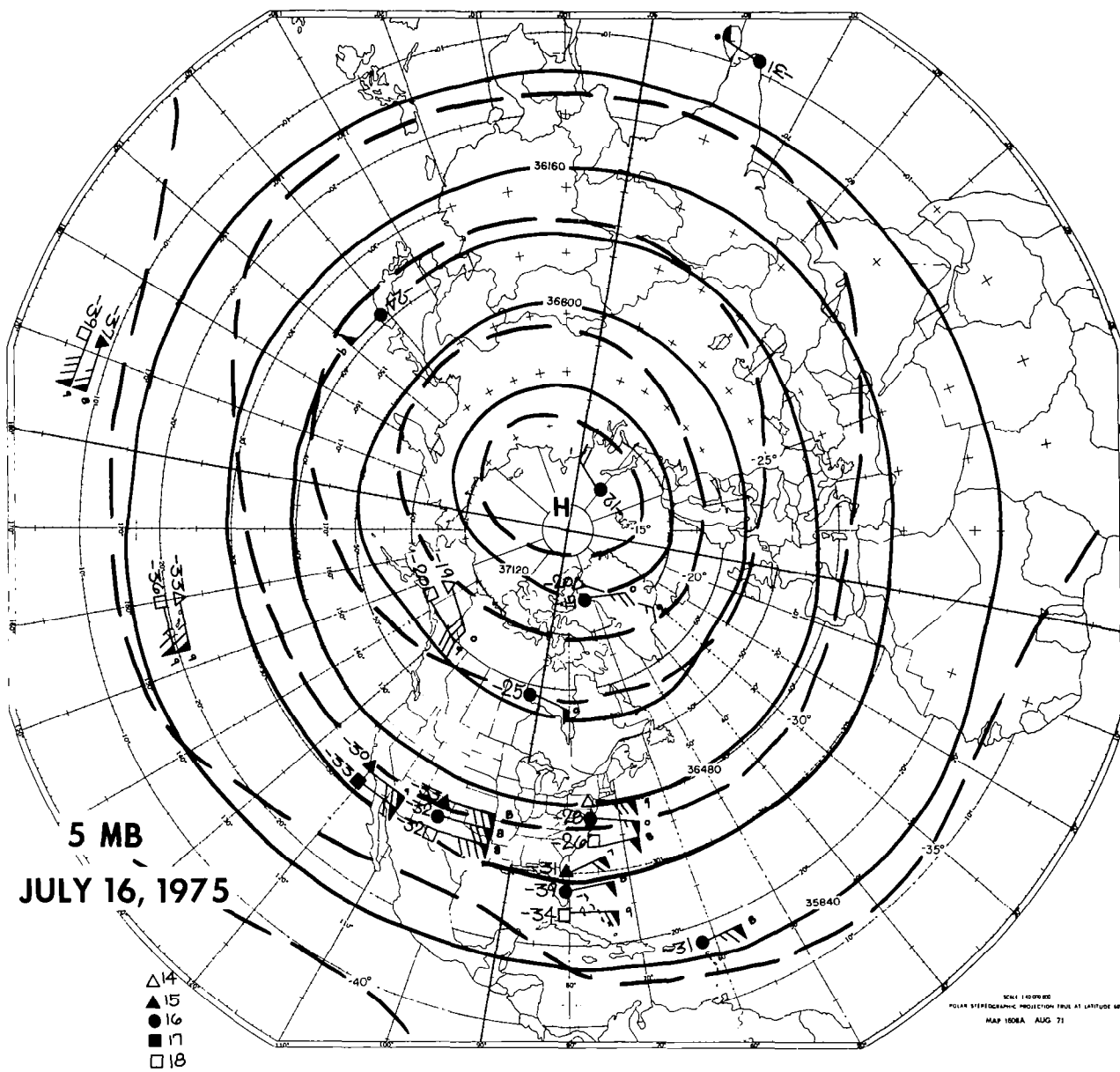


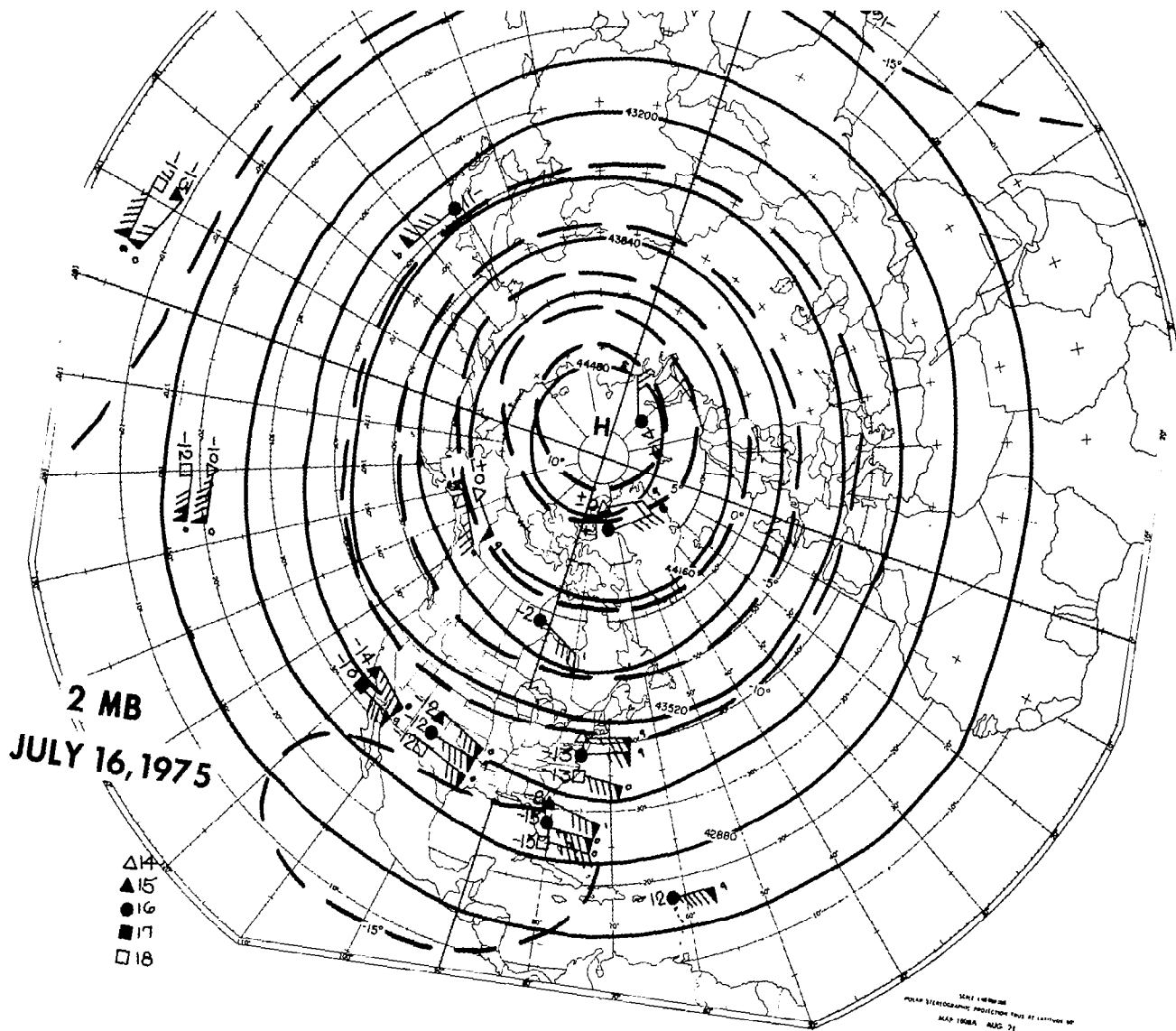




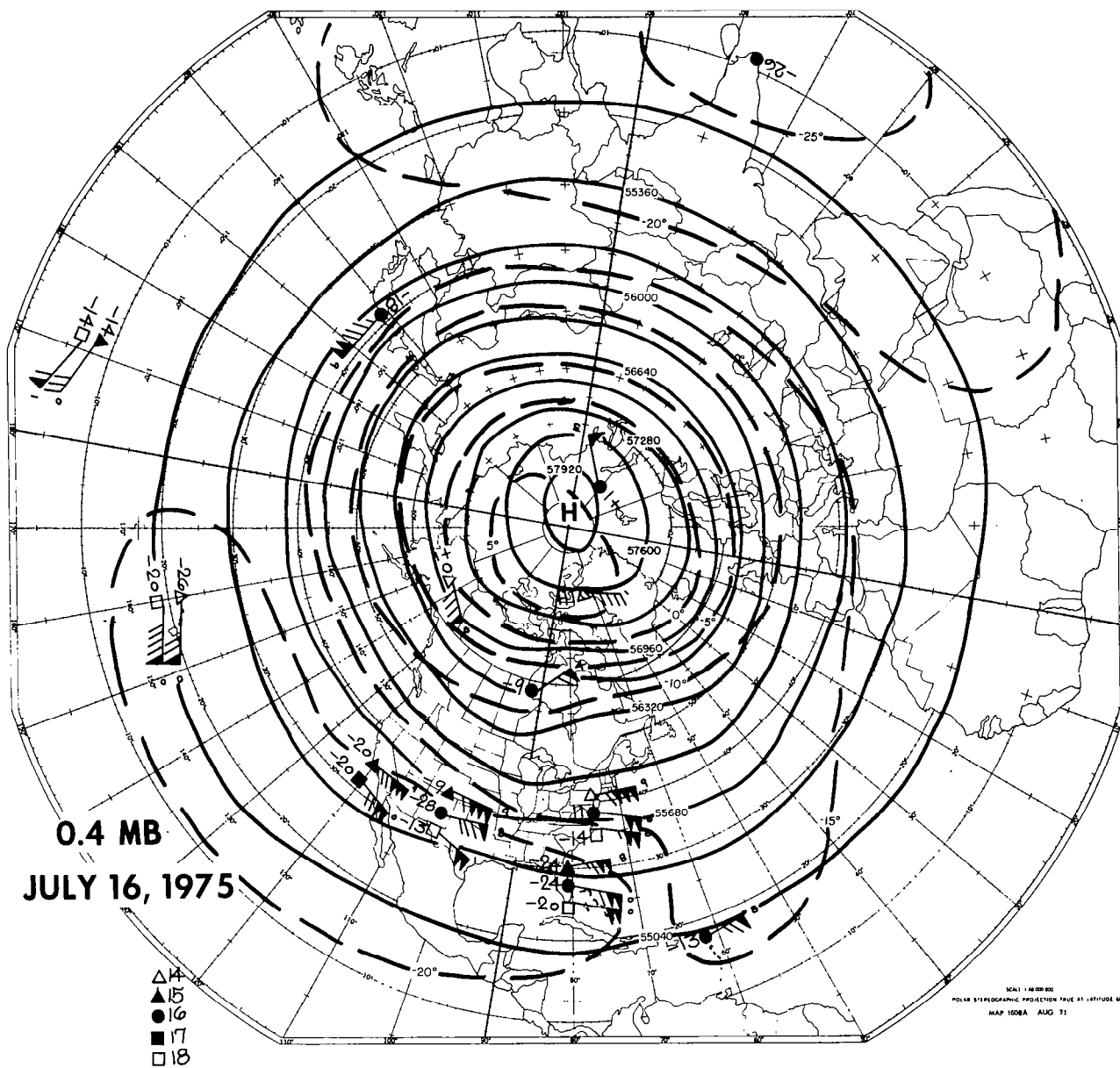


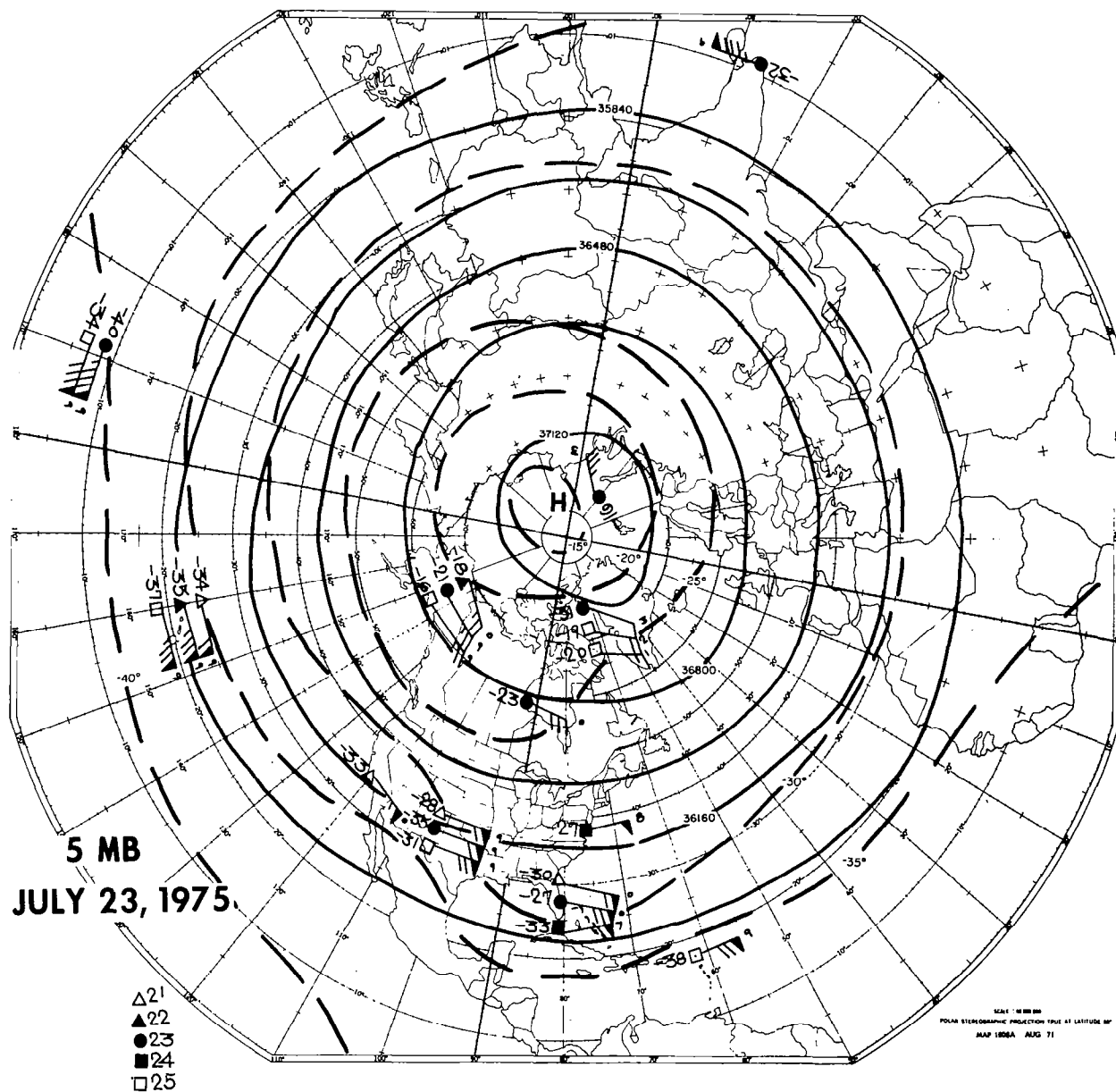


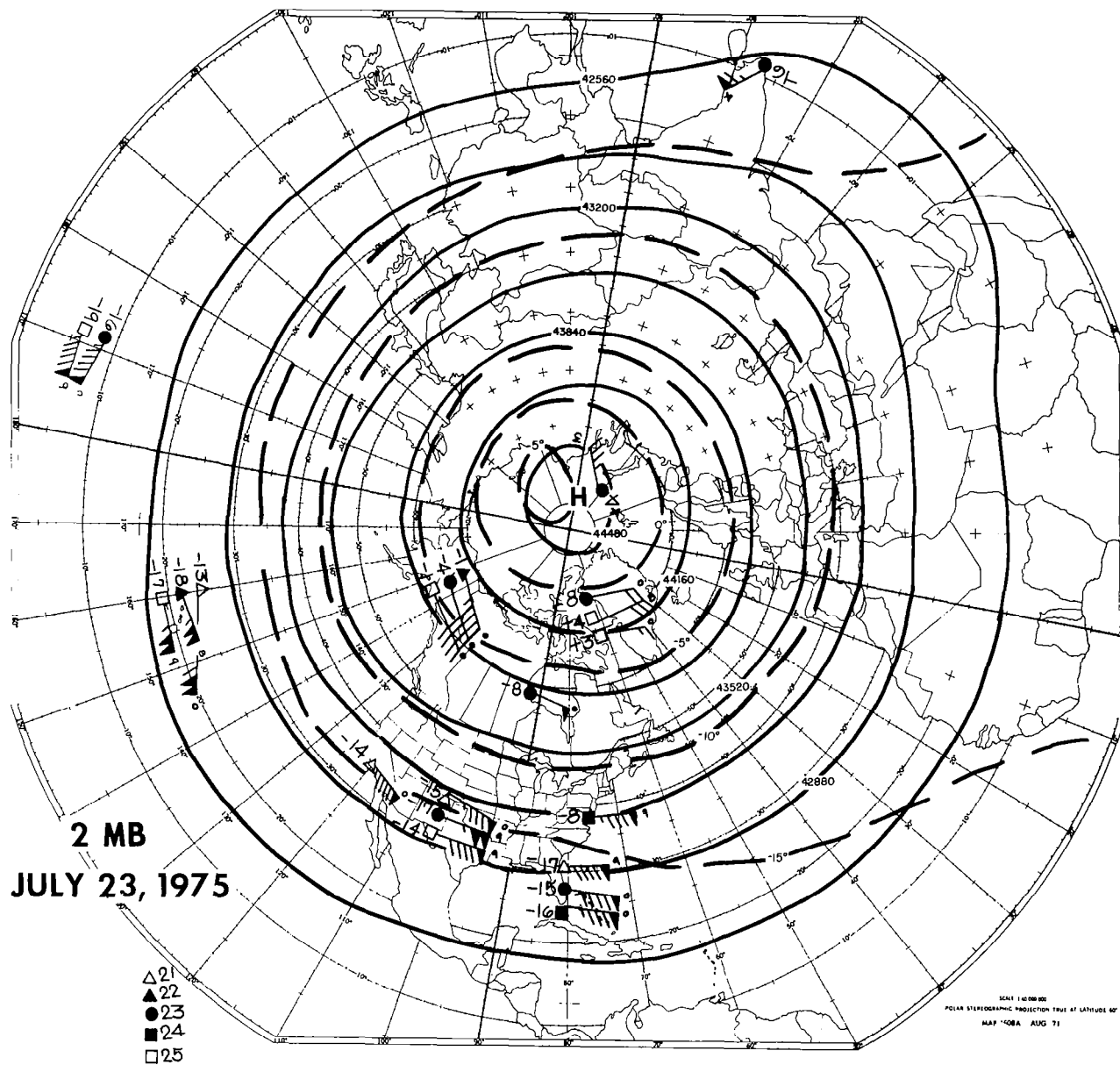


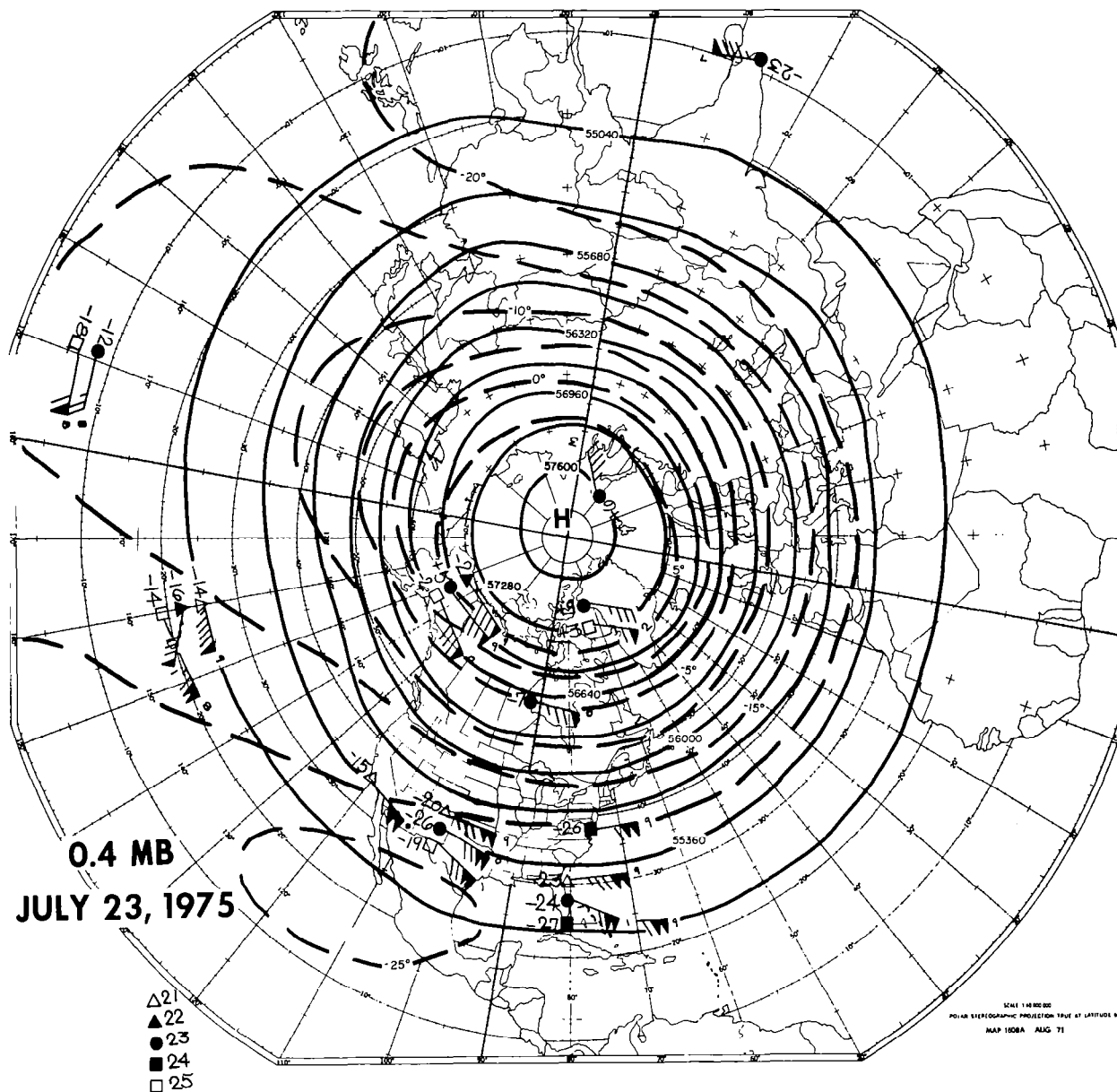


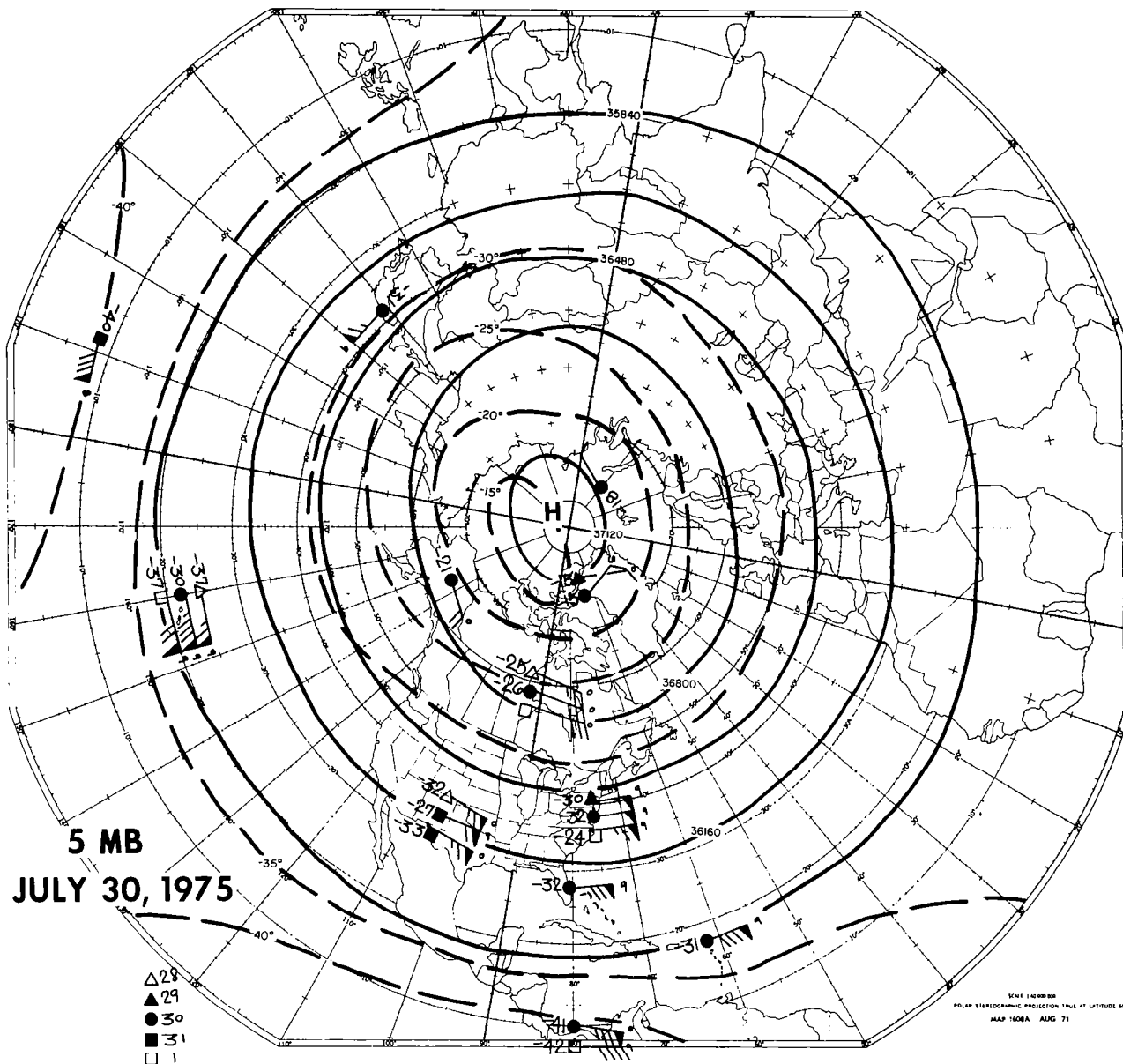


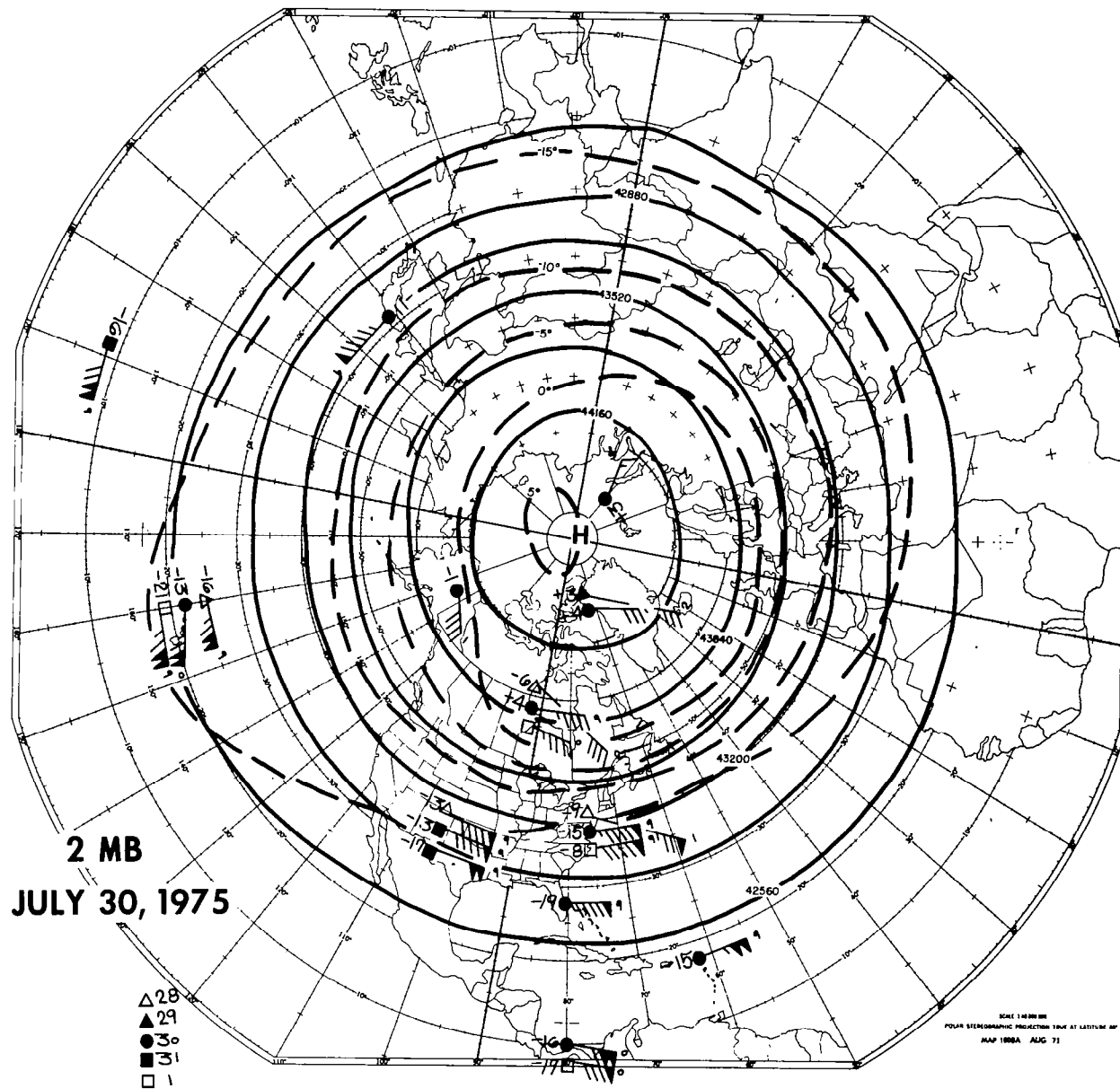


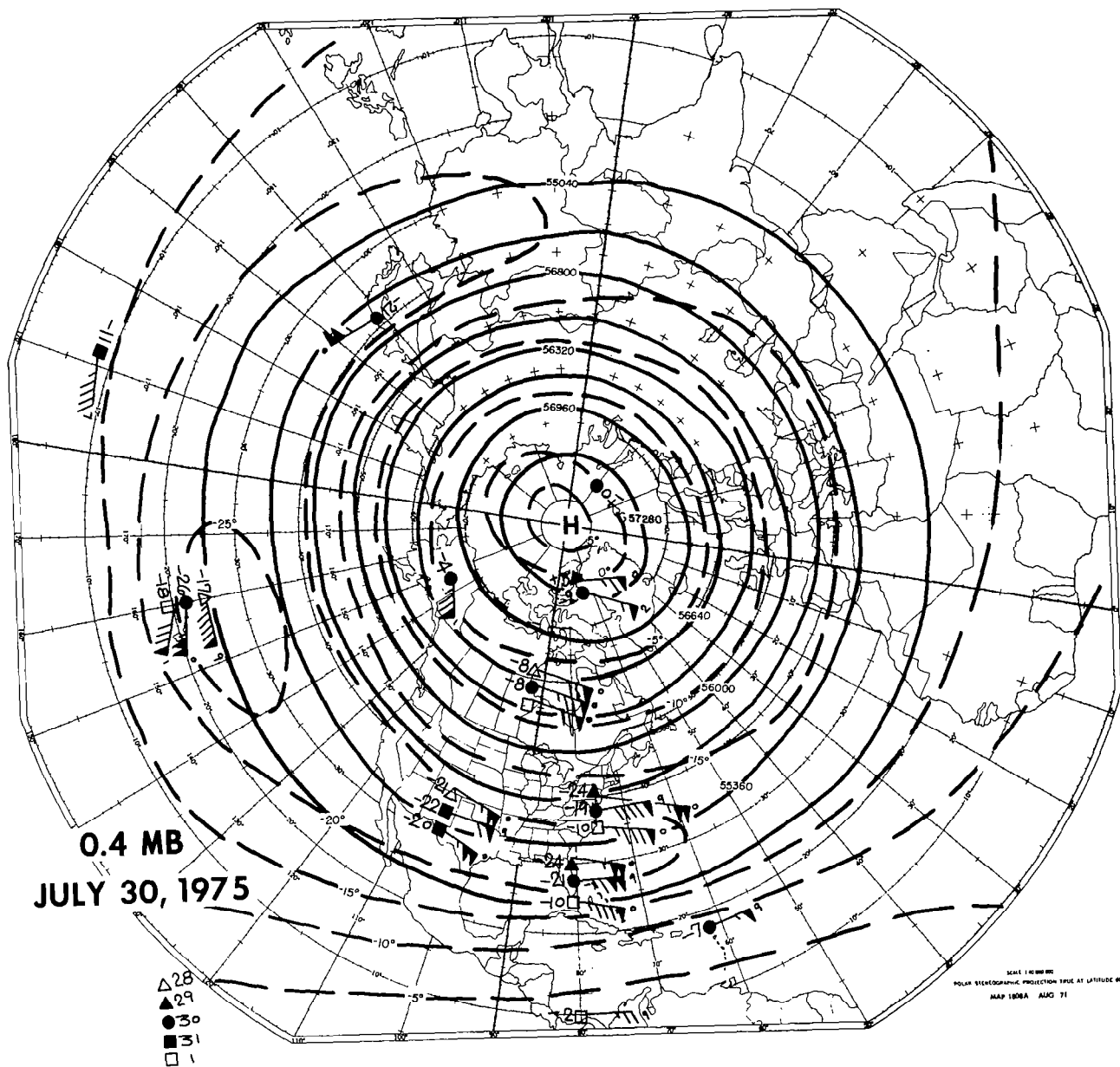


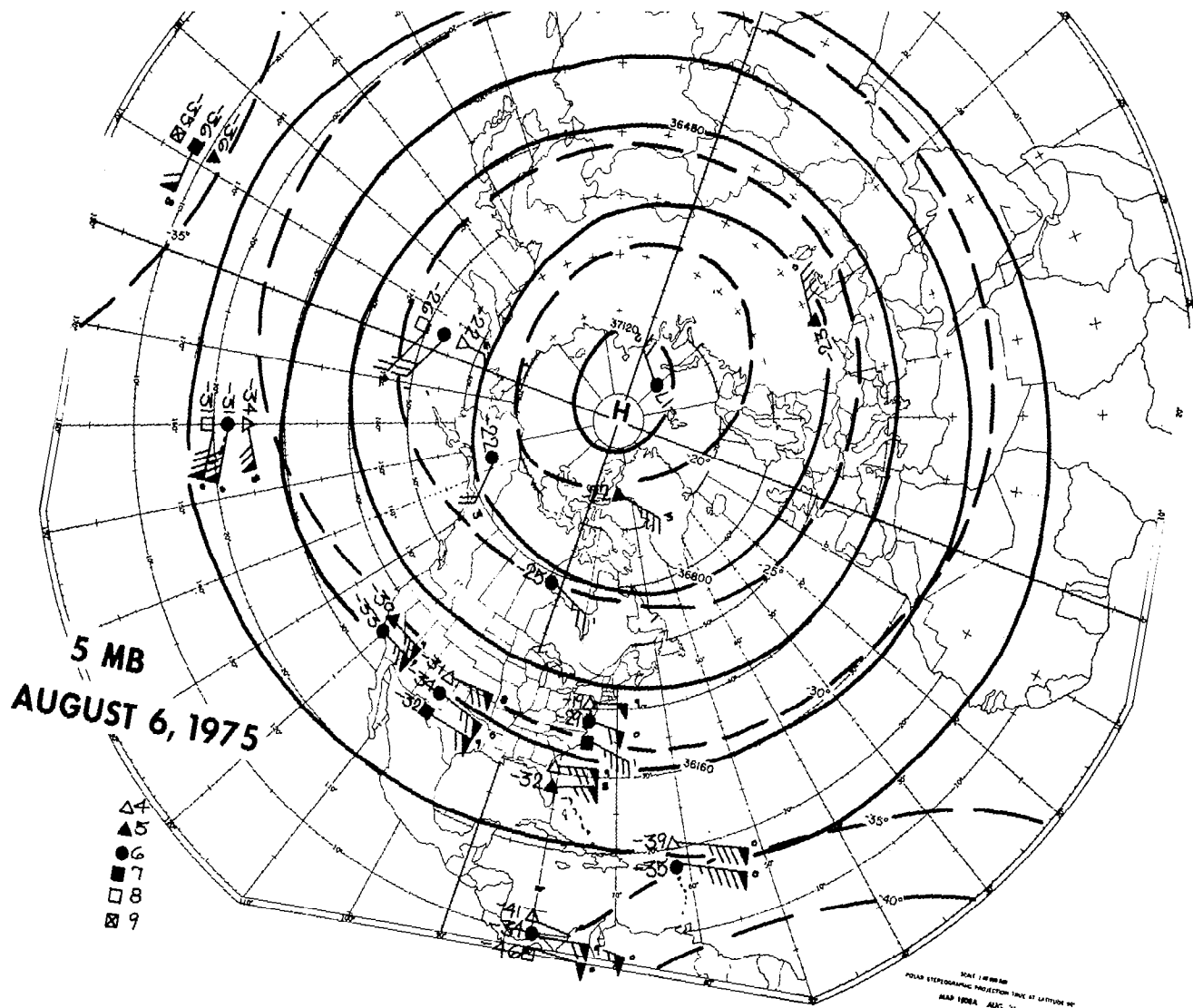




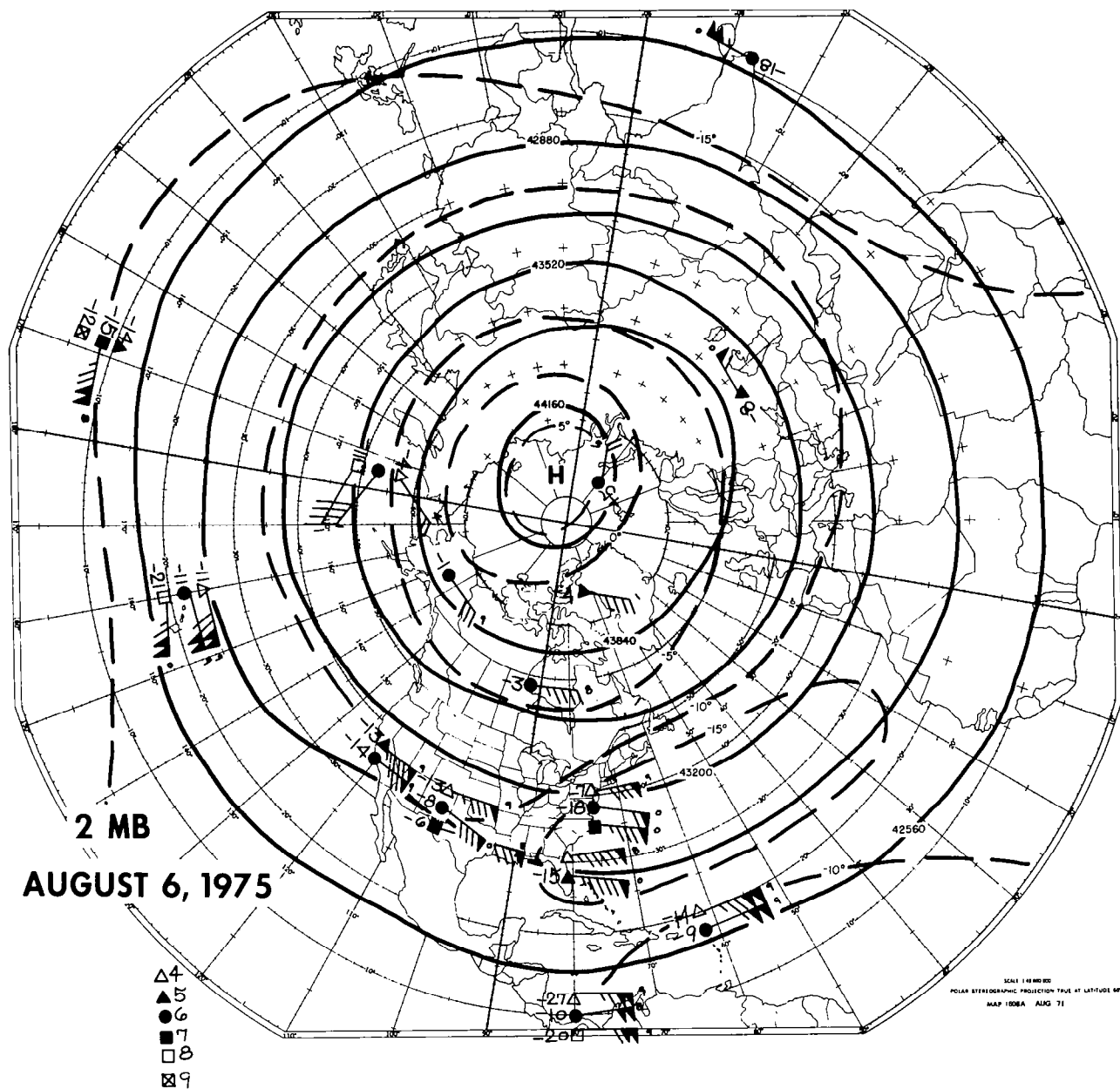


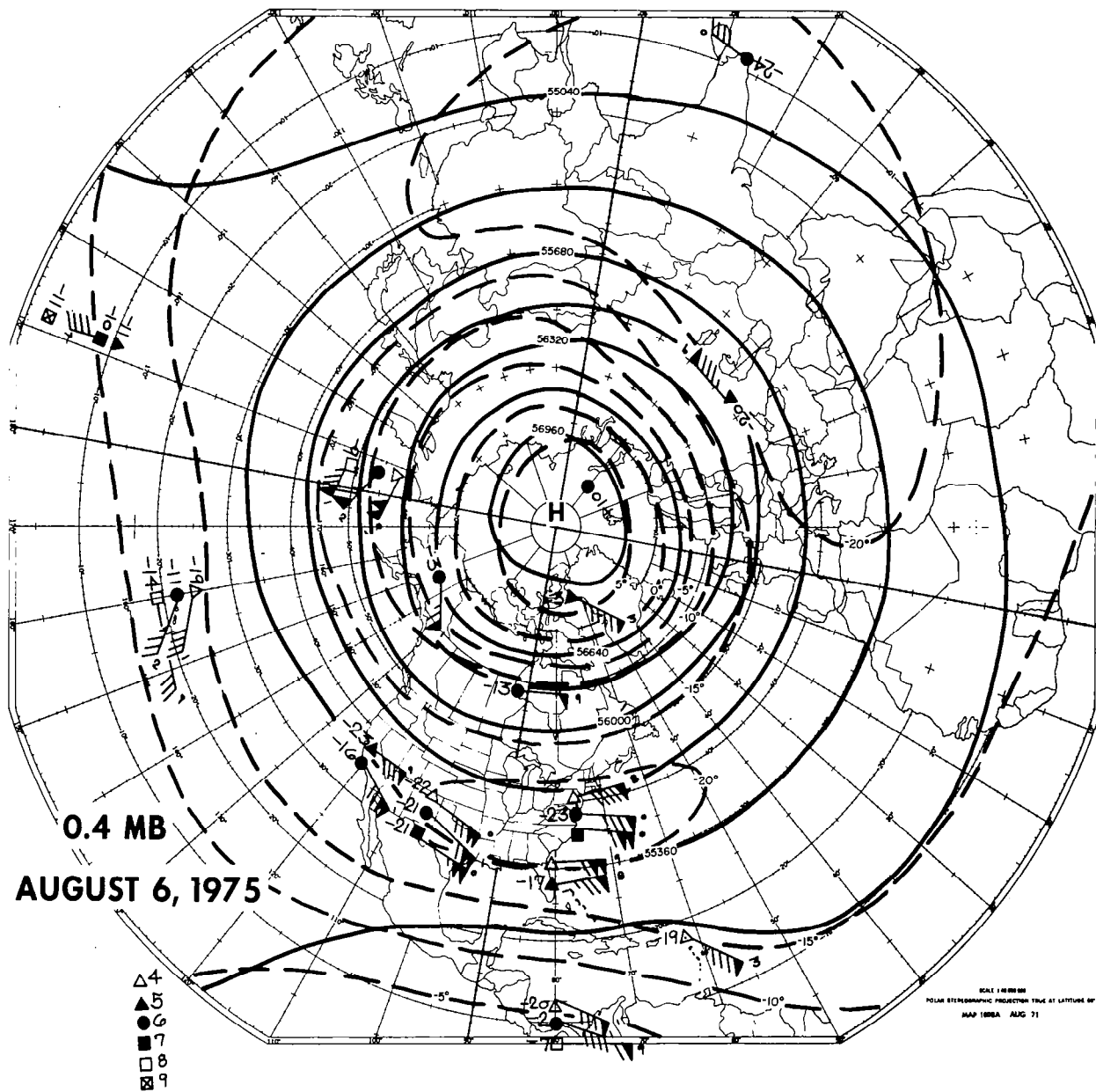


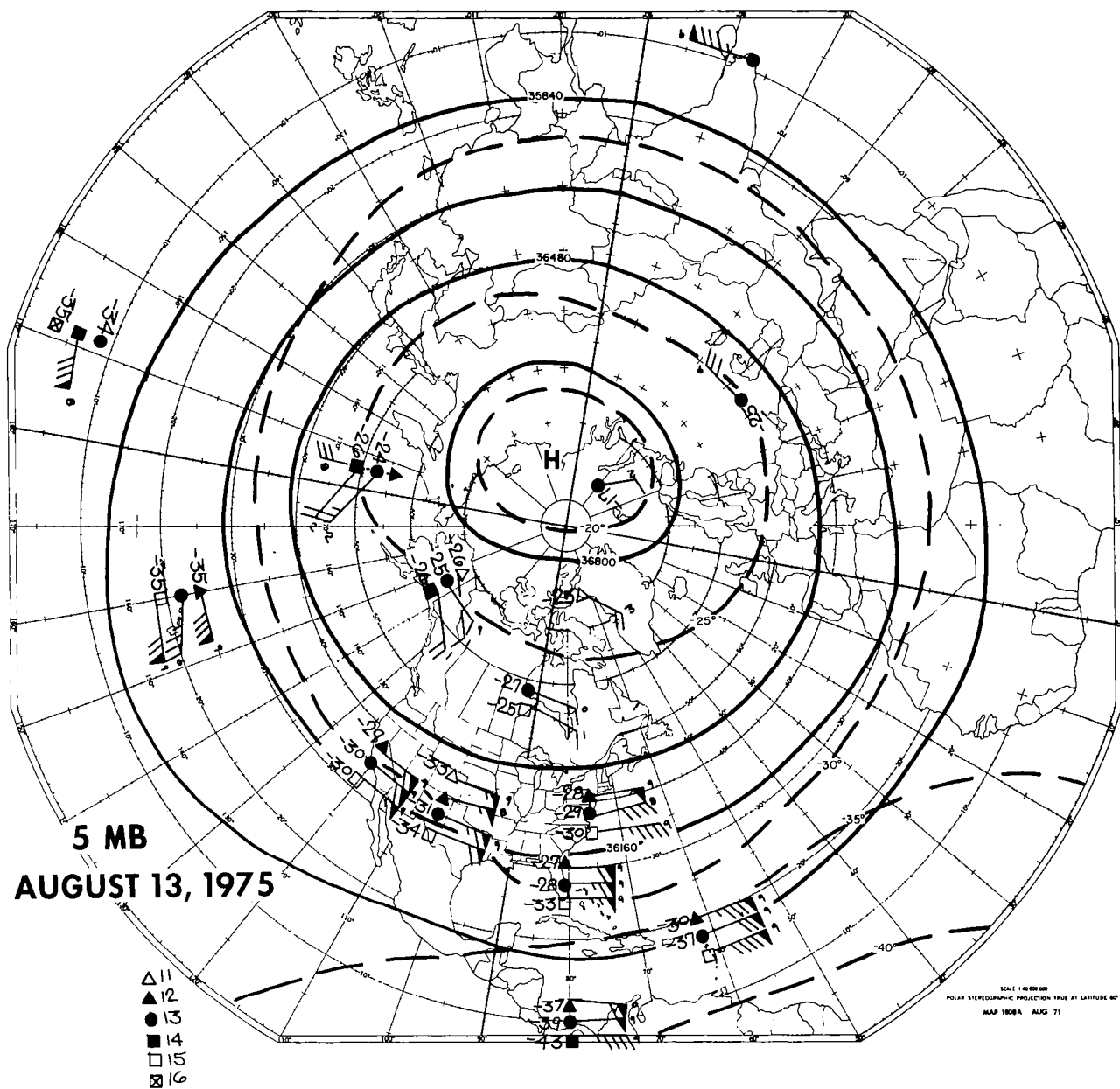


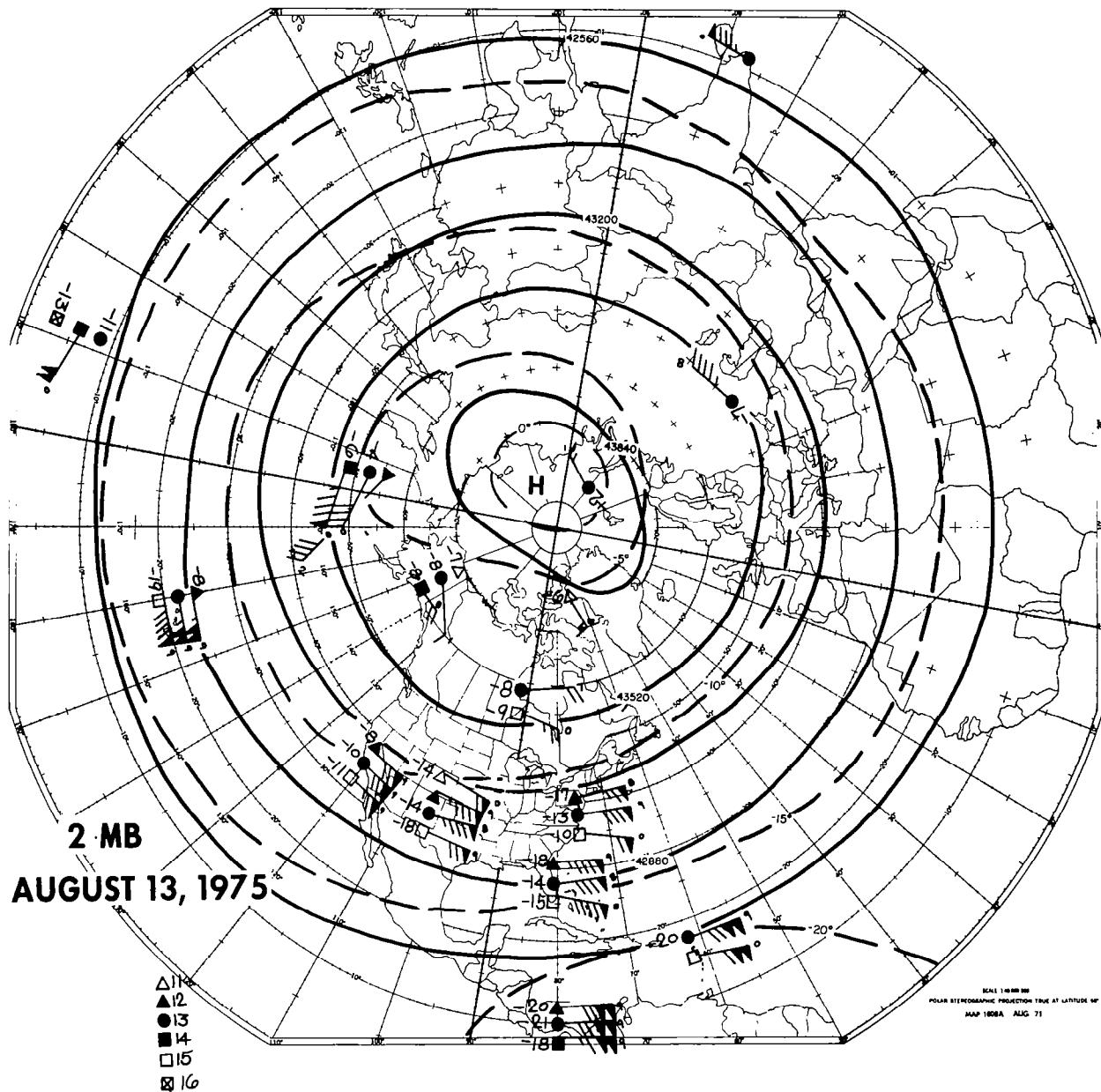


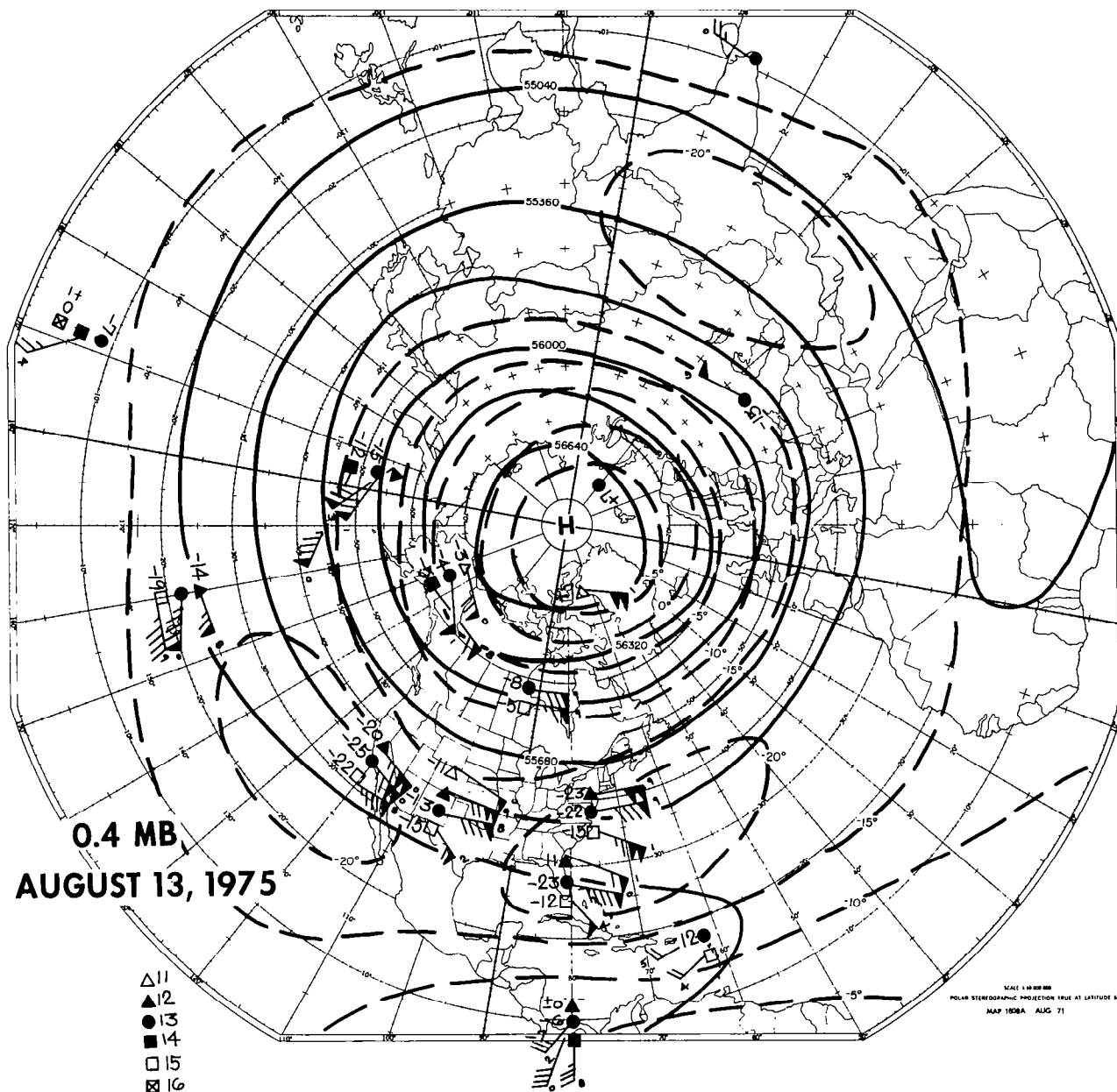


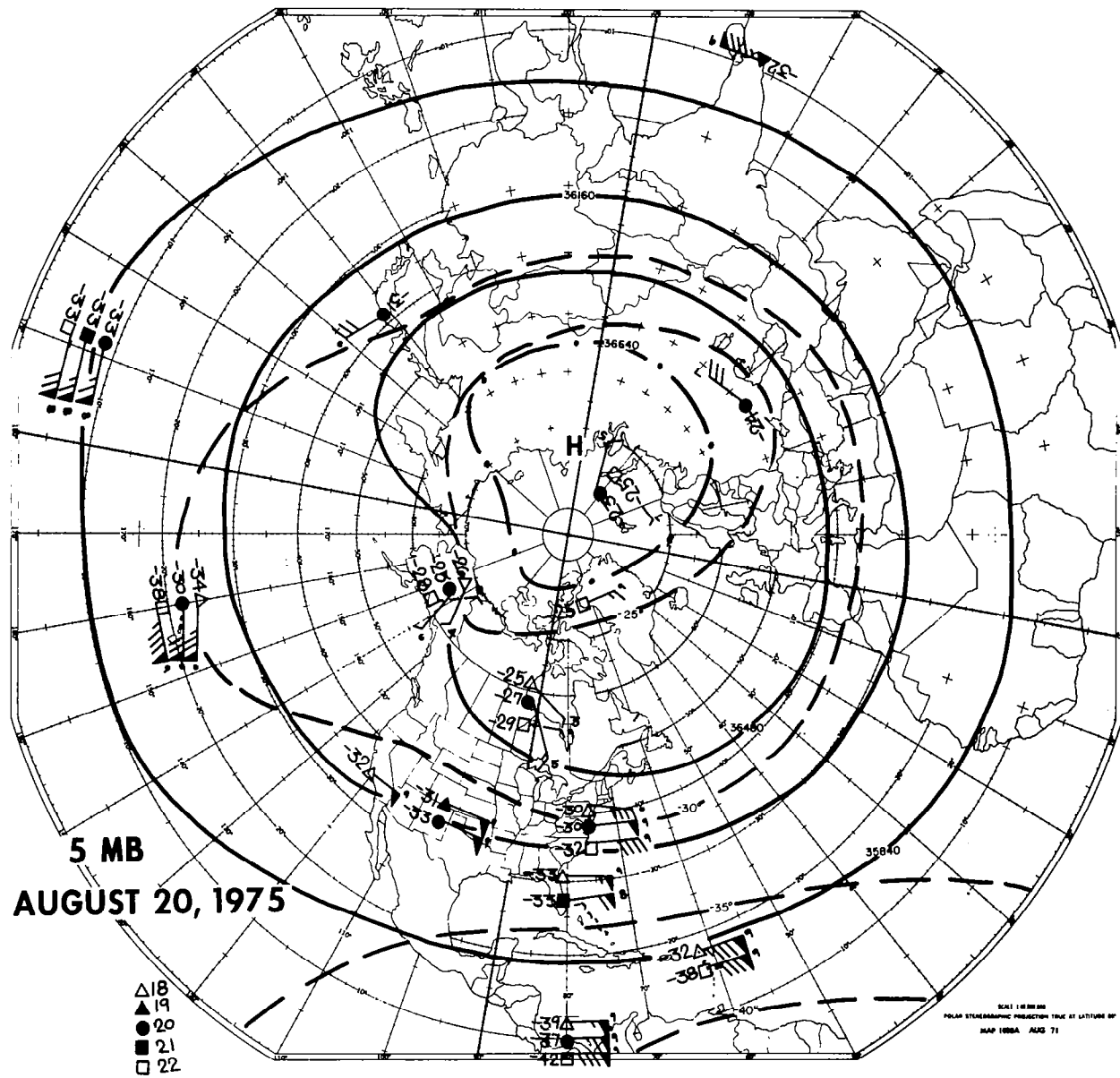


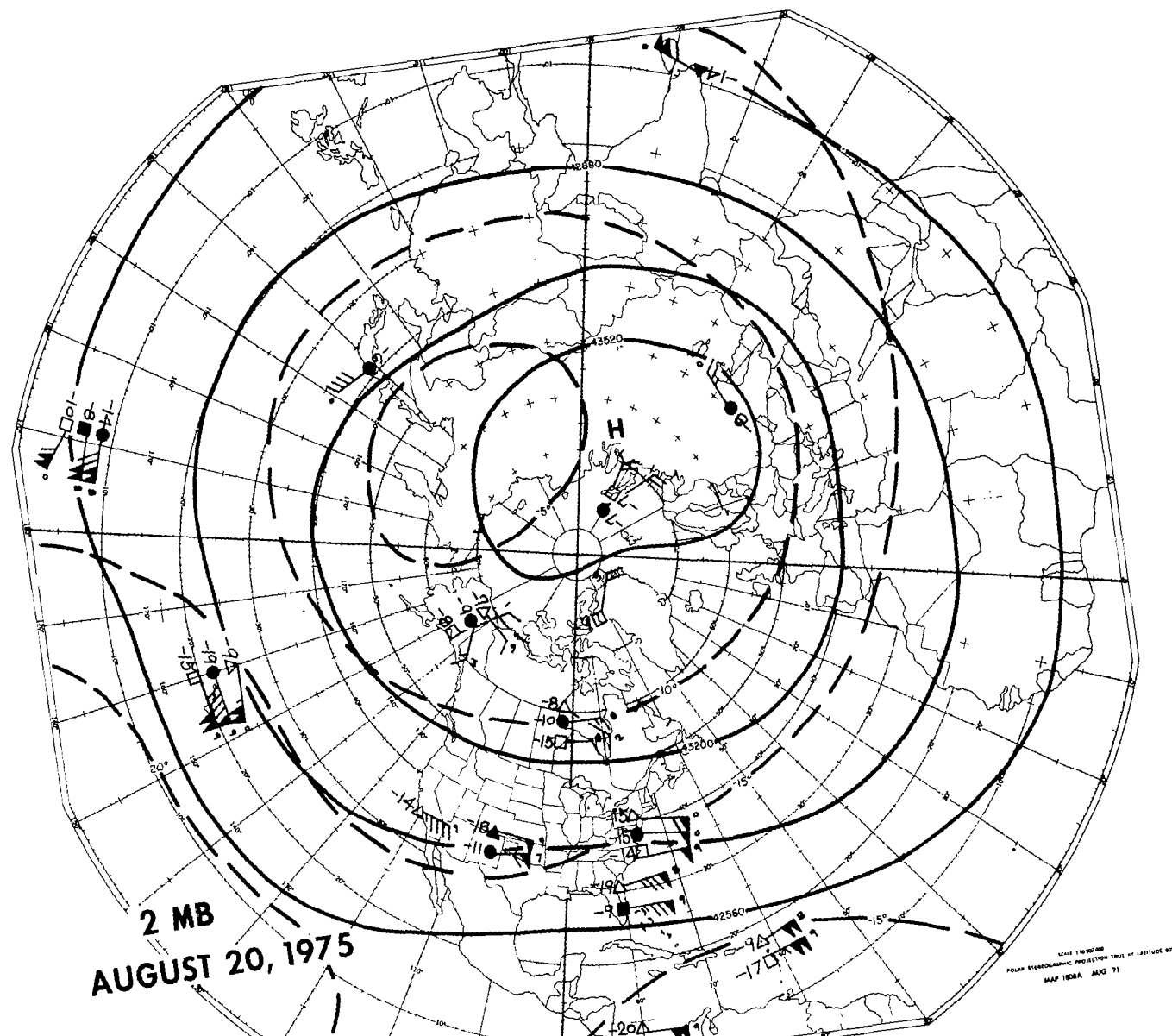


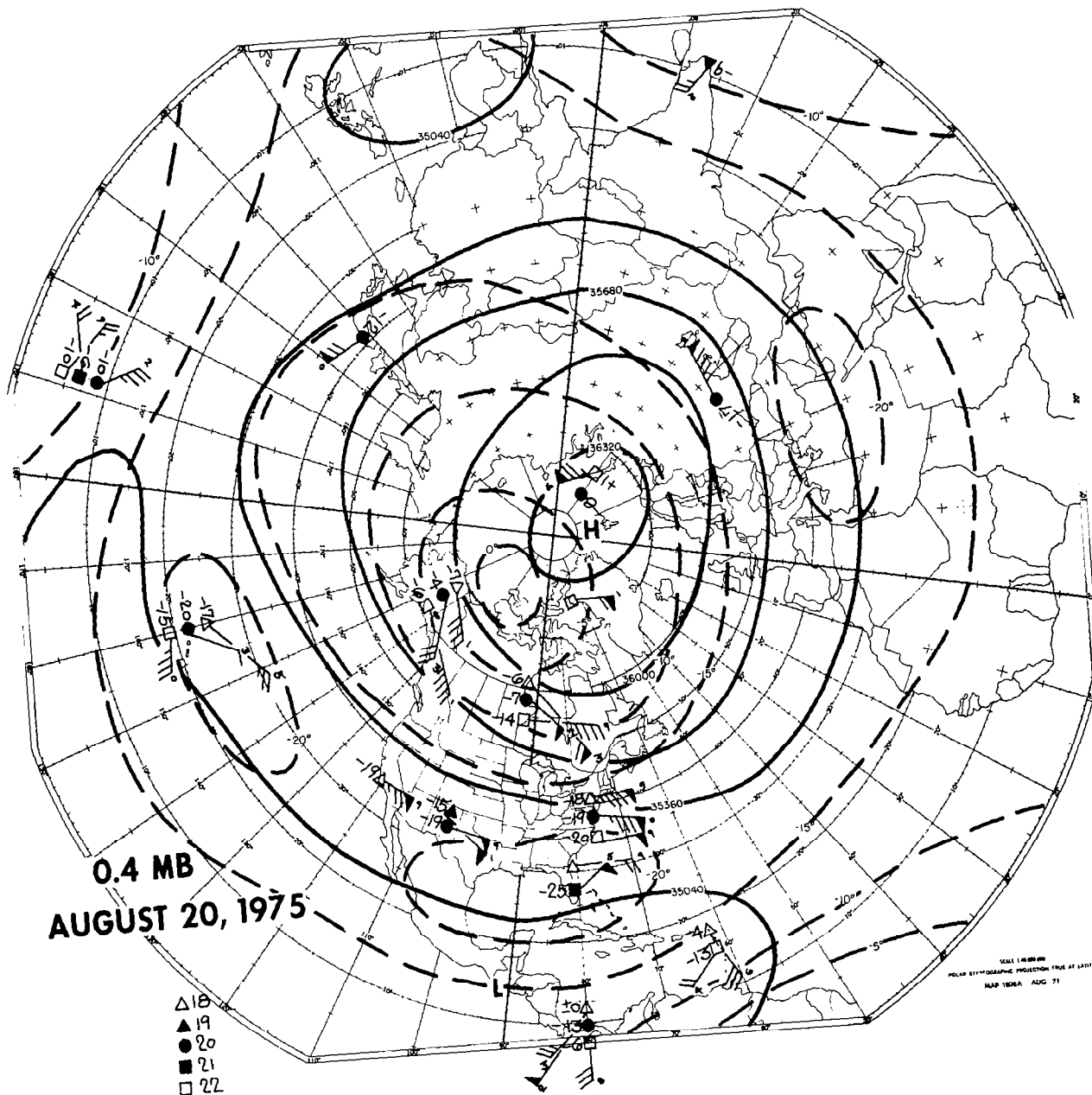




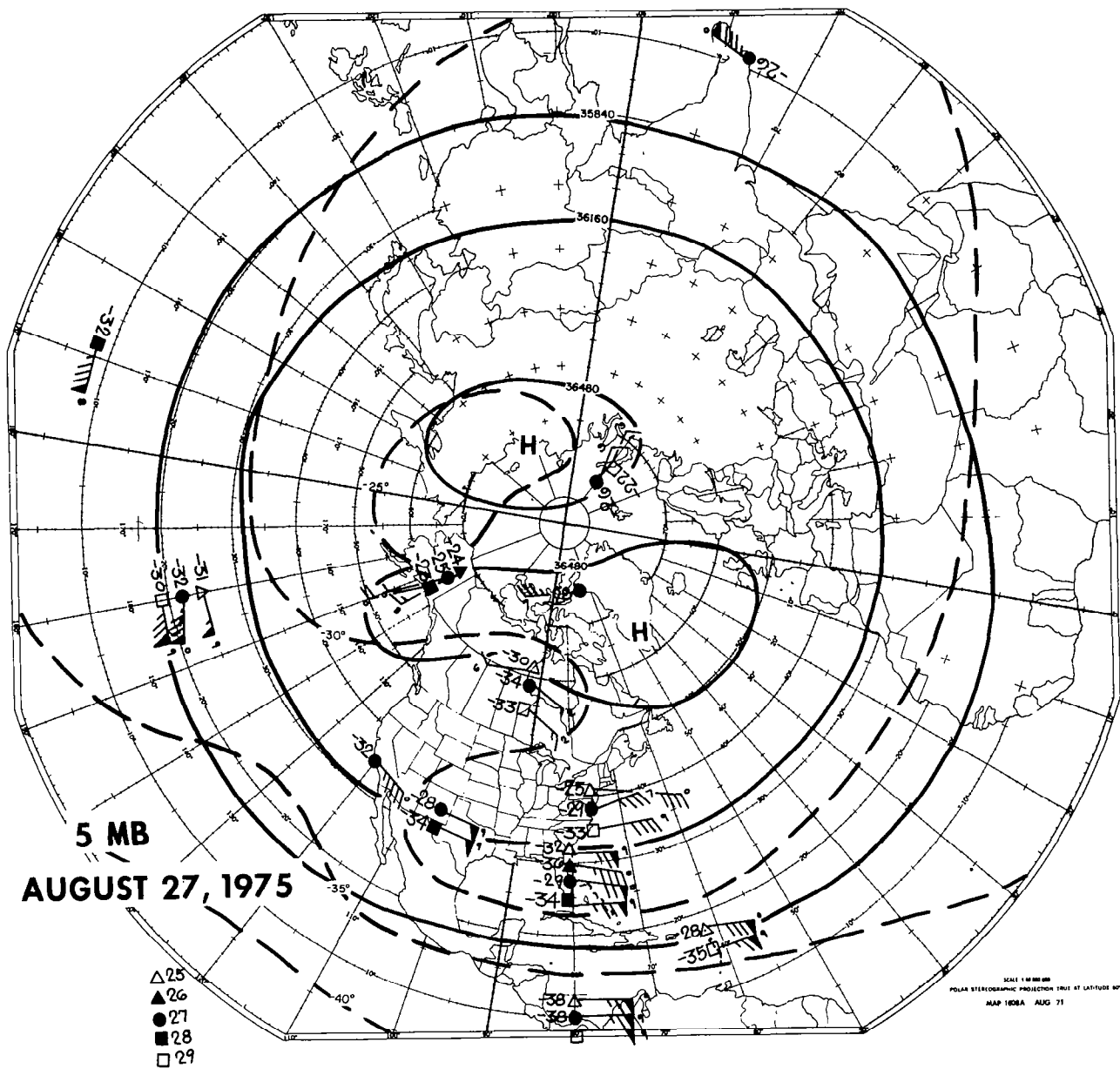


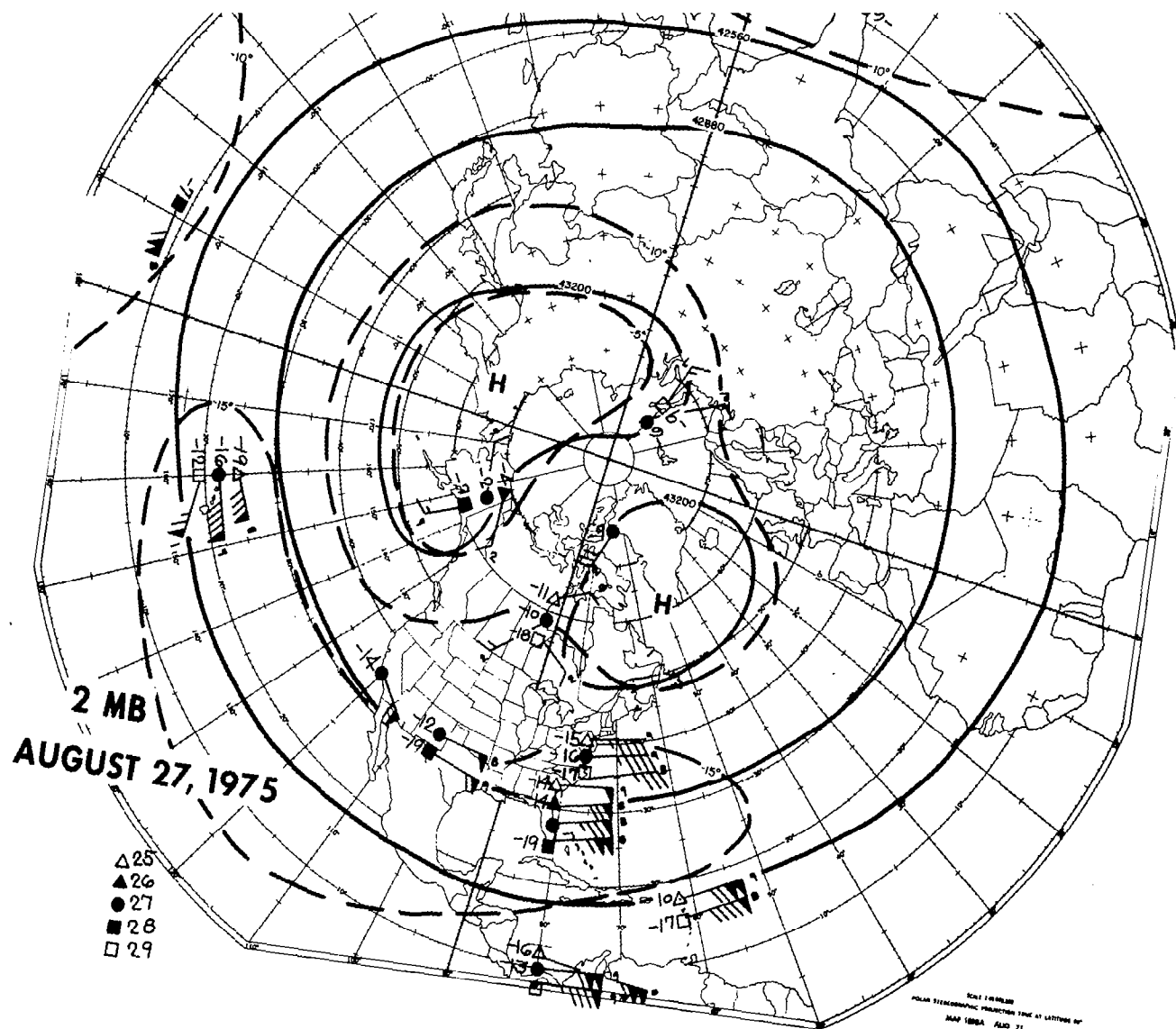


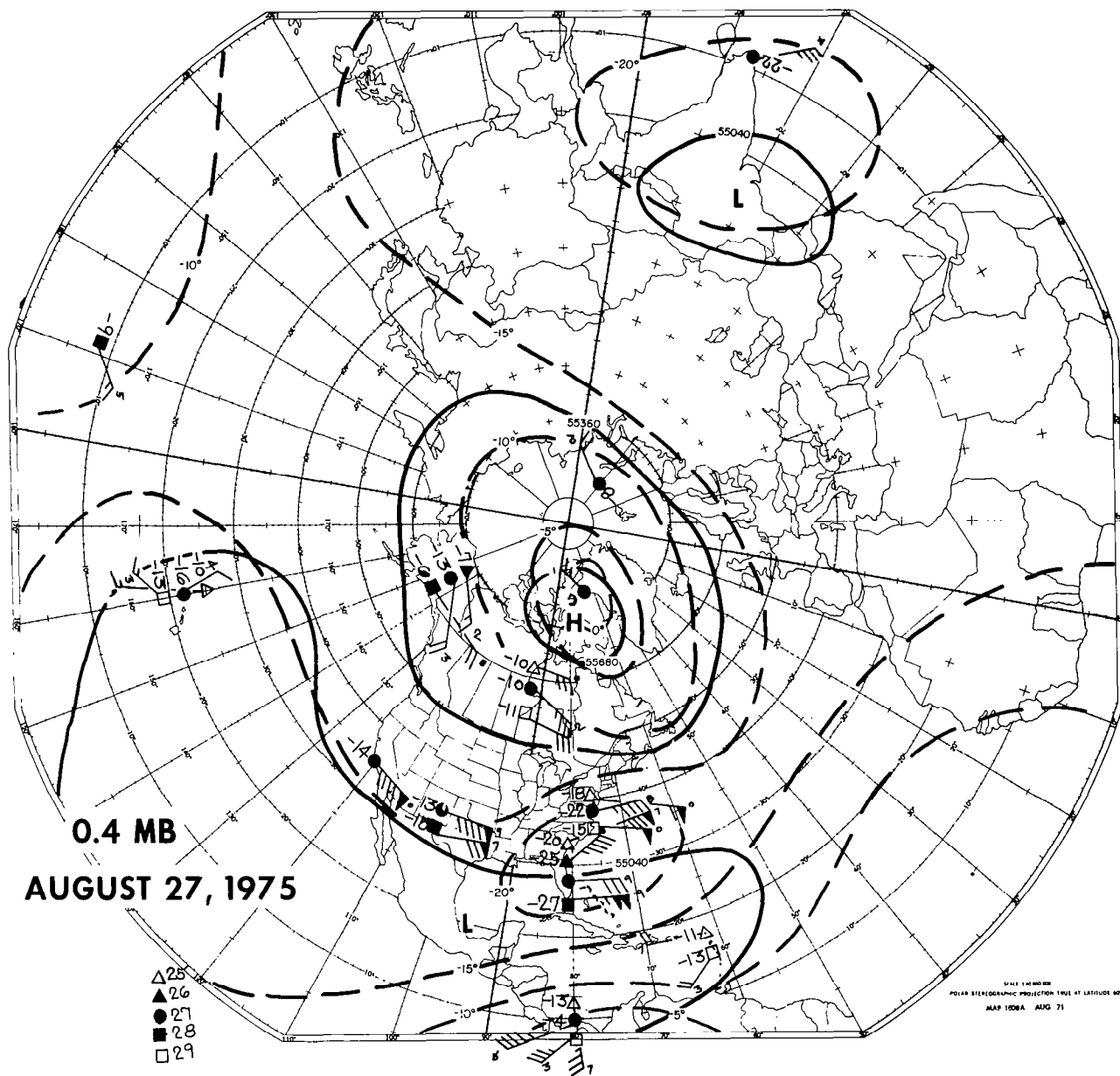


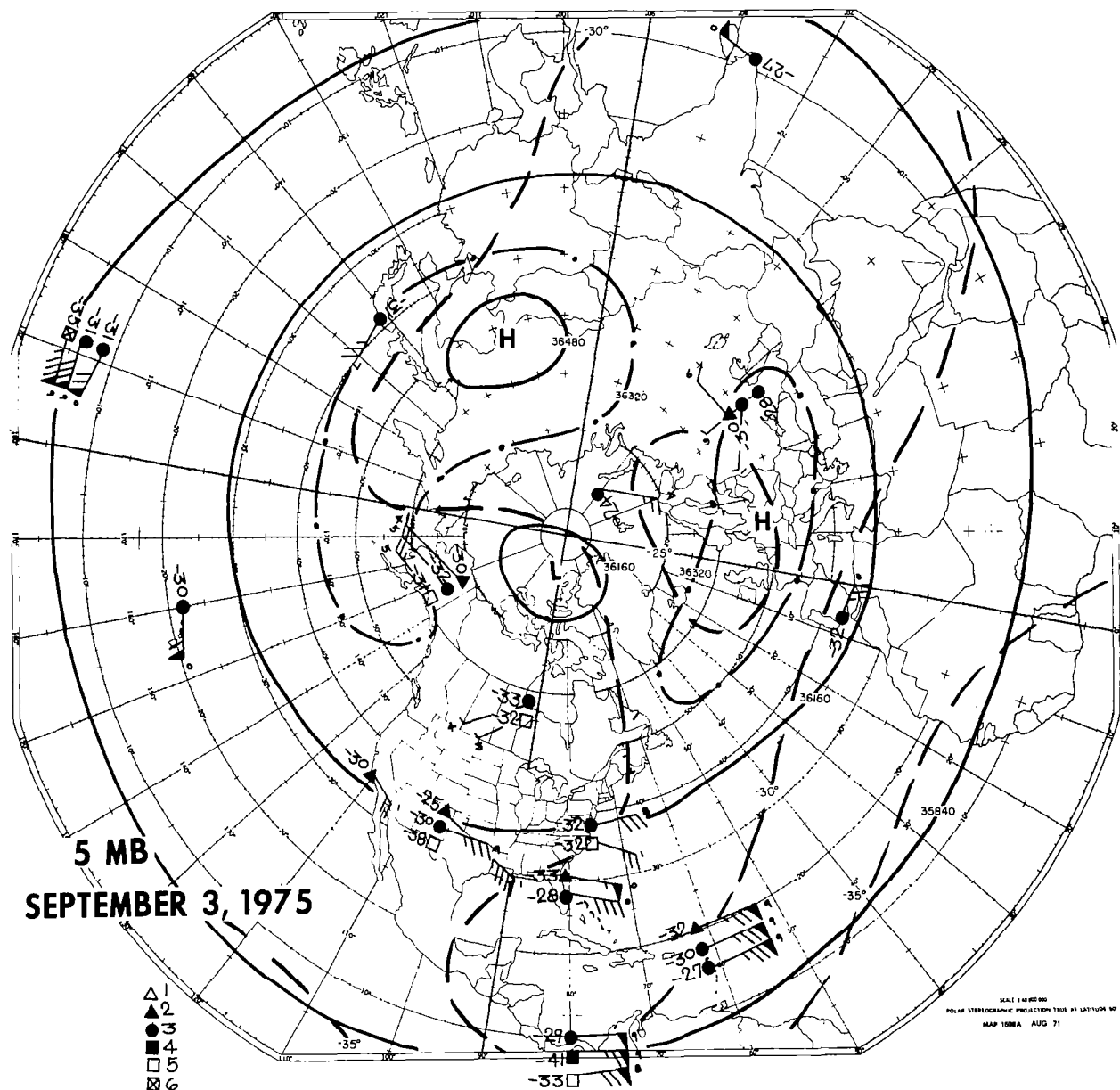








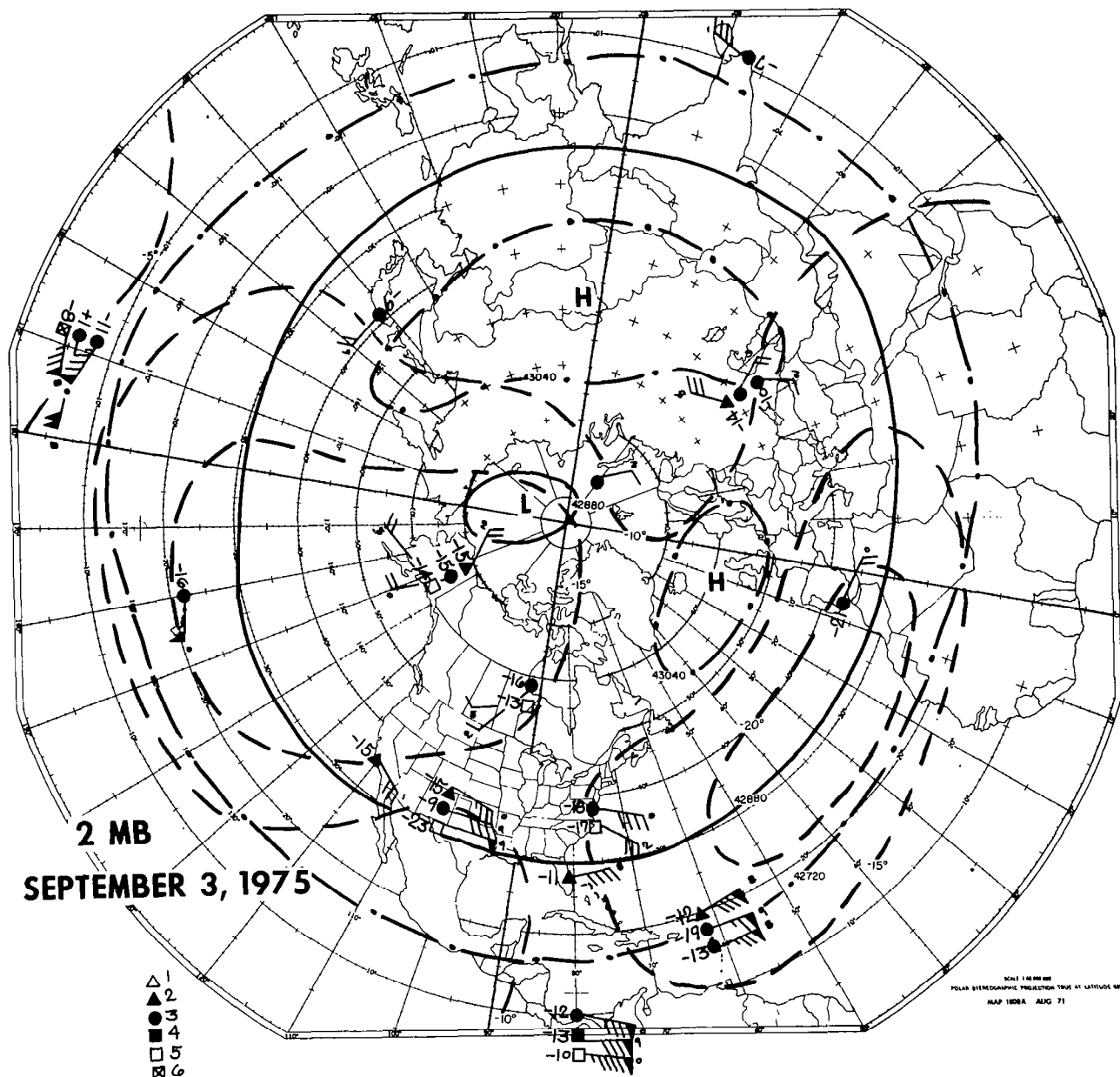


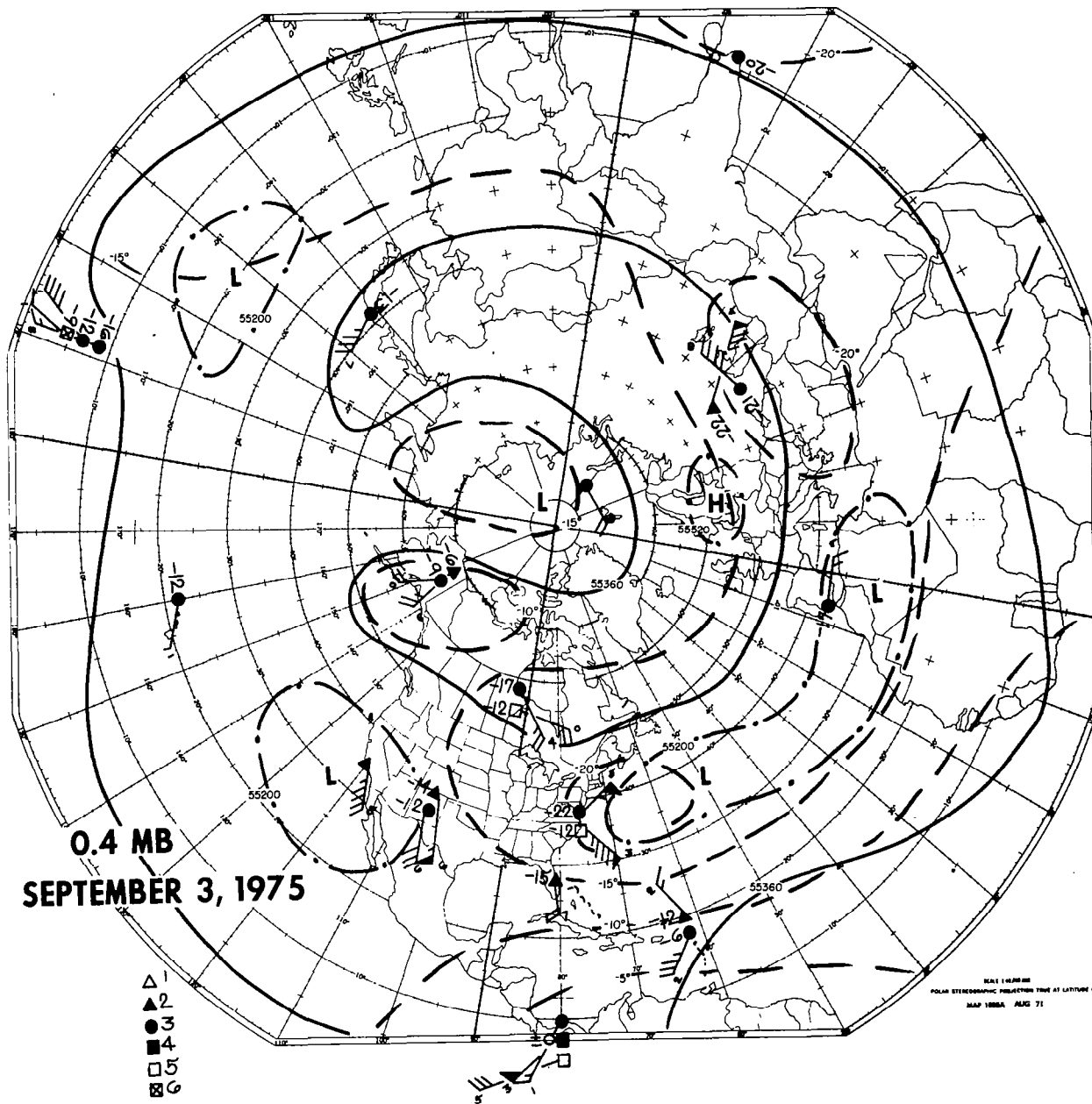


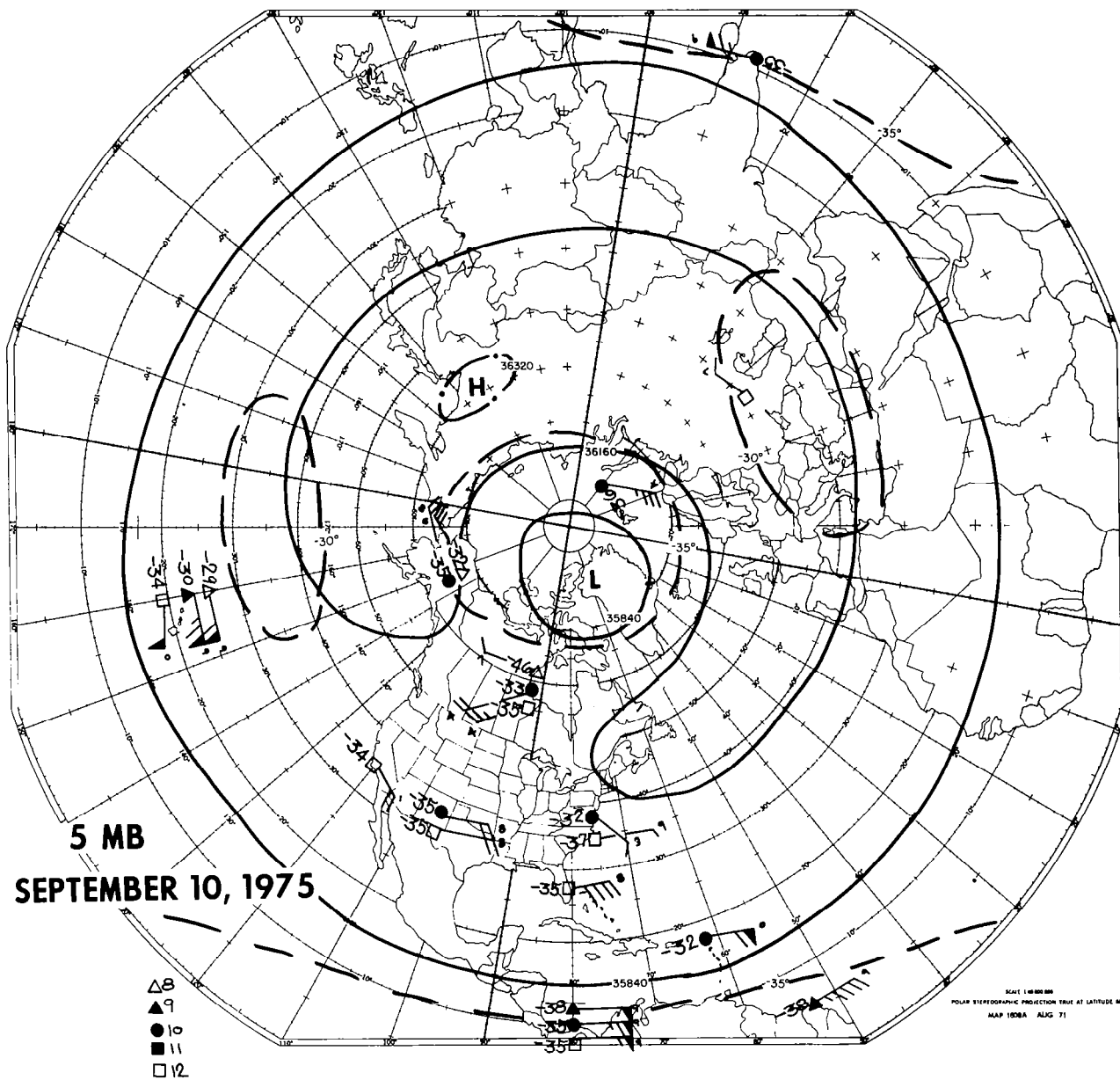
5 MB  
SEPTEMBER 3, 1975

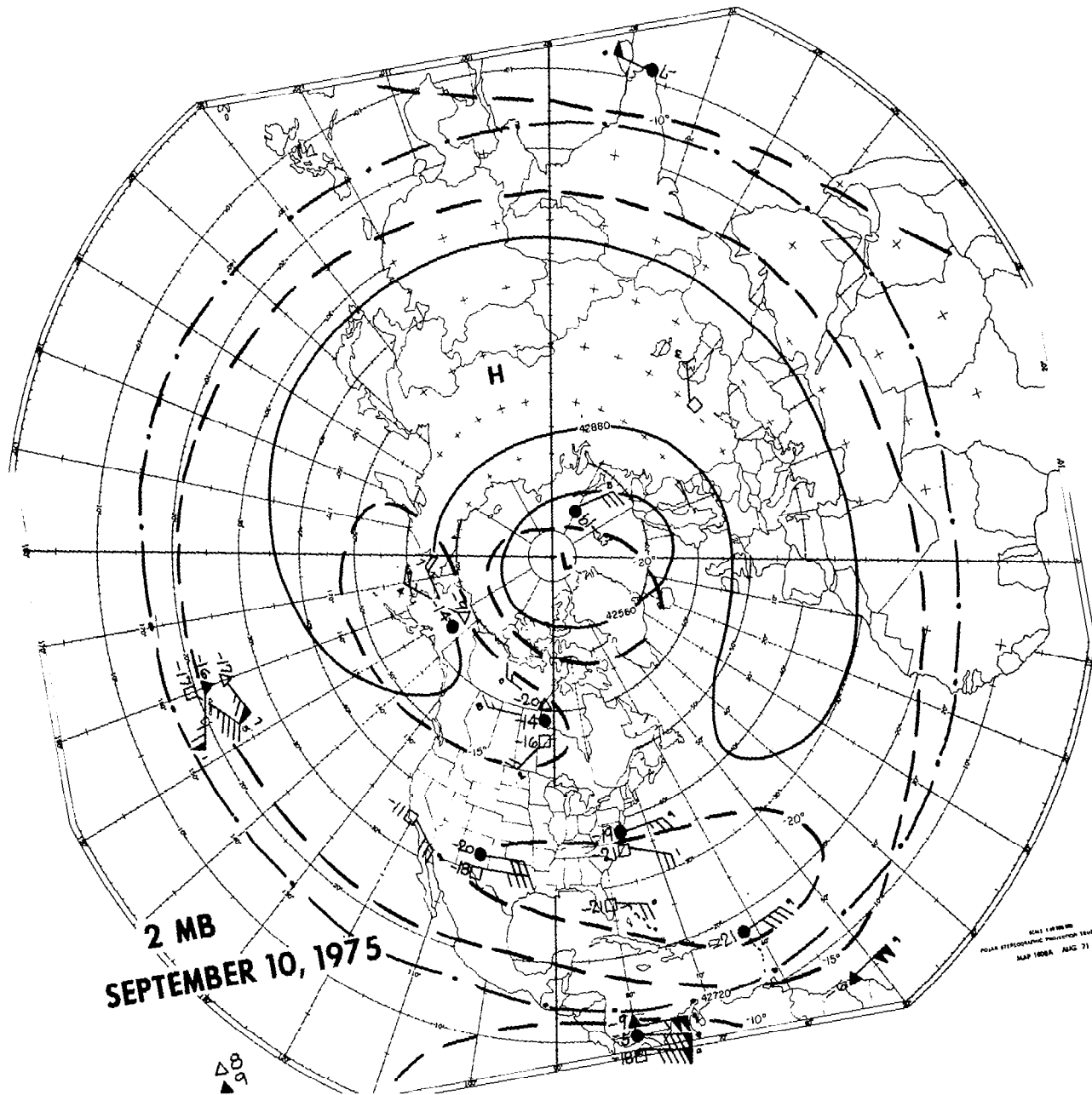
- △ 1
- 2
- 3
- 4
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- ⊠ 6

SCALE 1:1000000  
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 90°  
MAP 1008A AUG 71

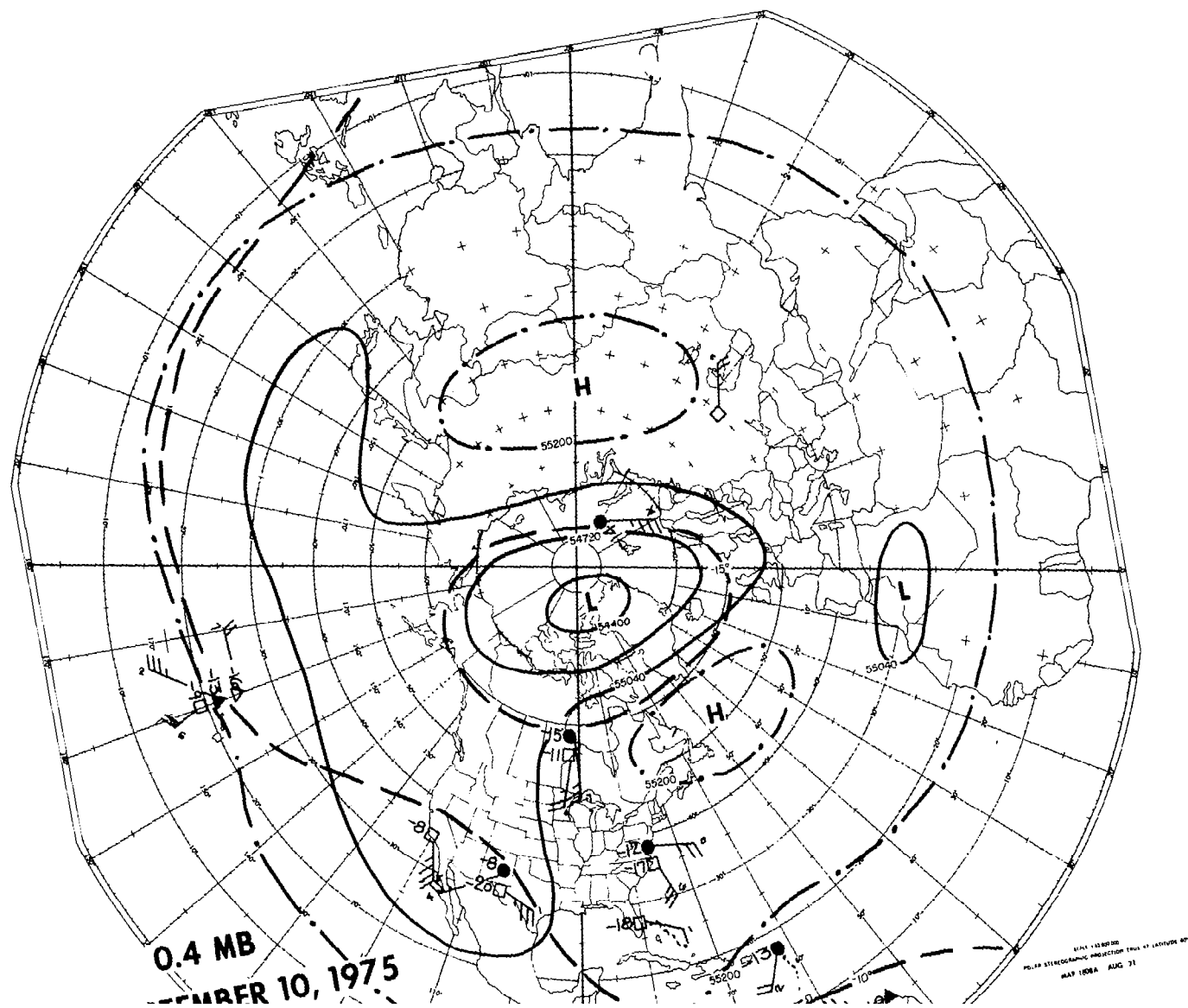


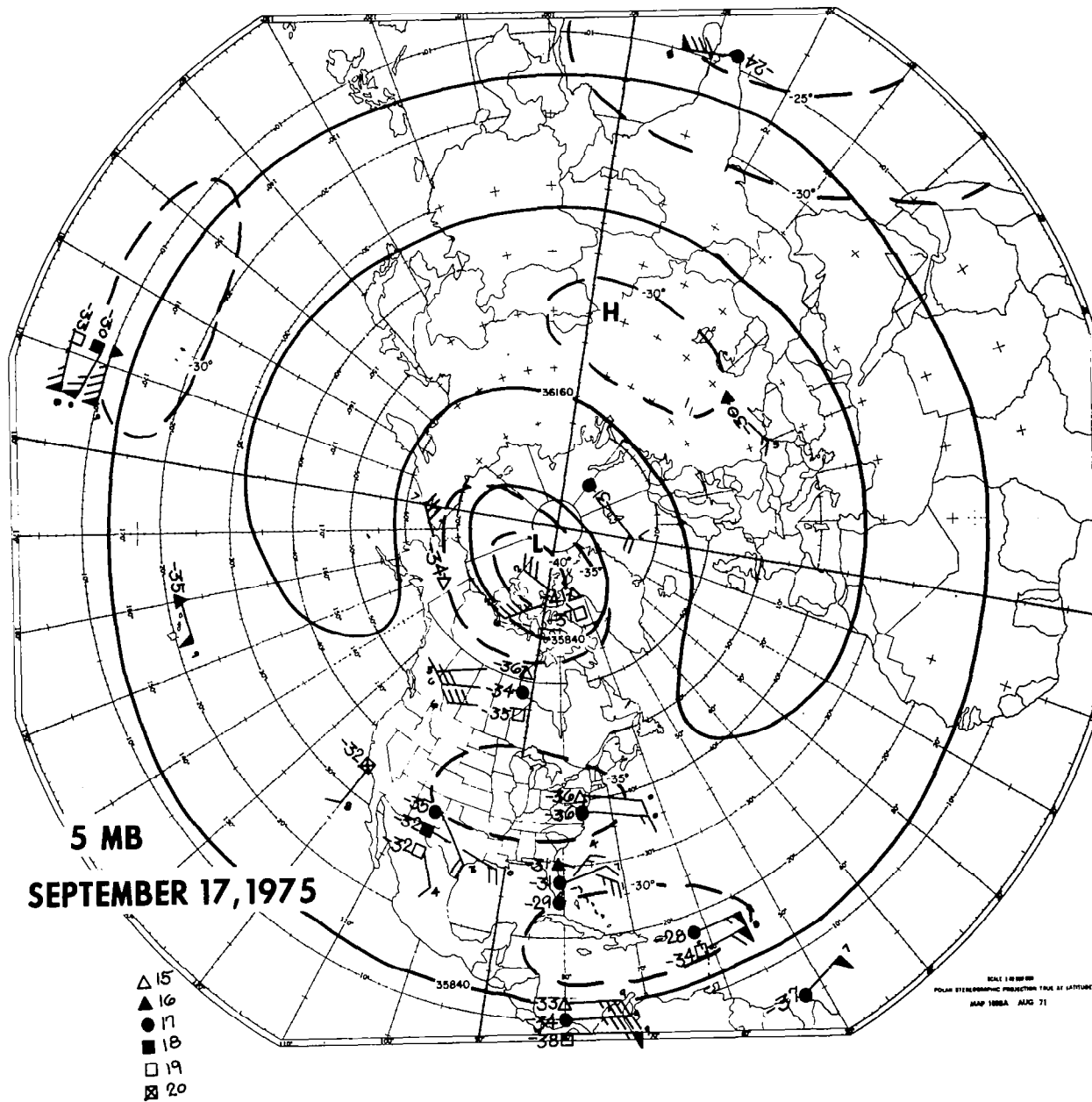


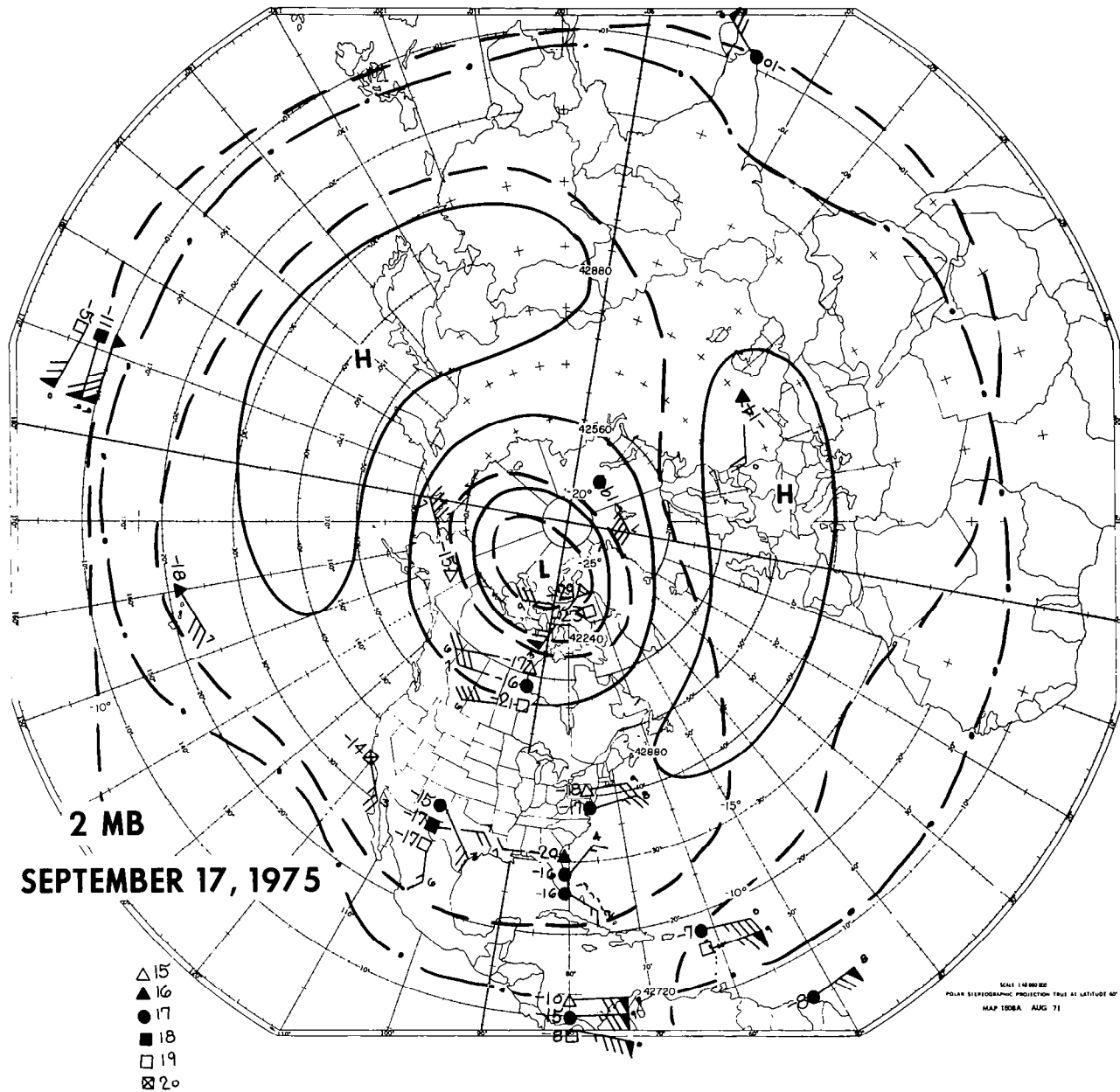


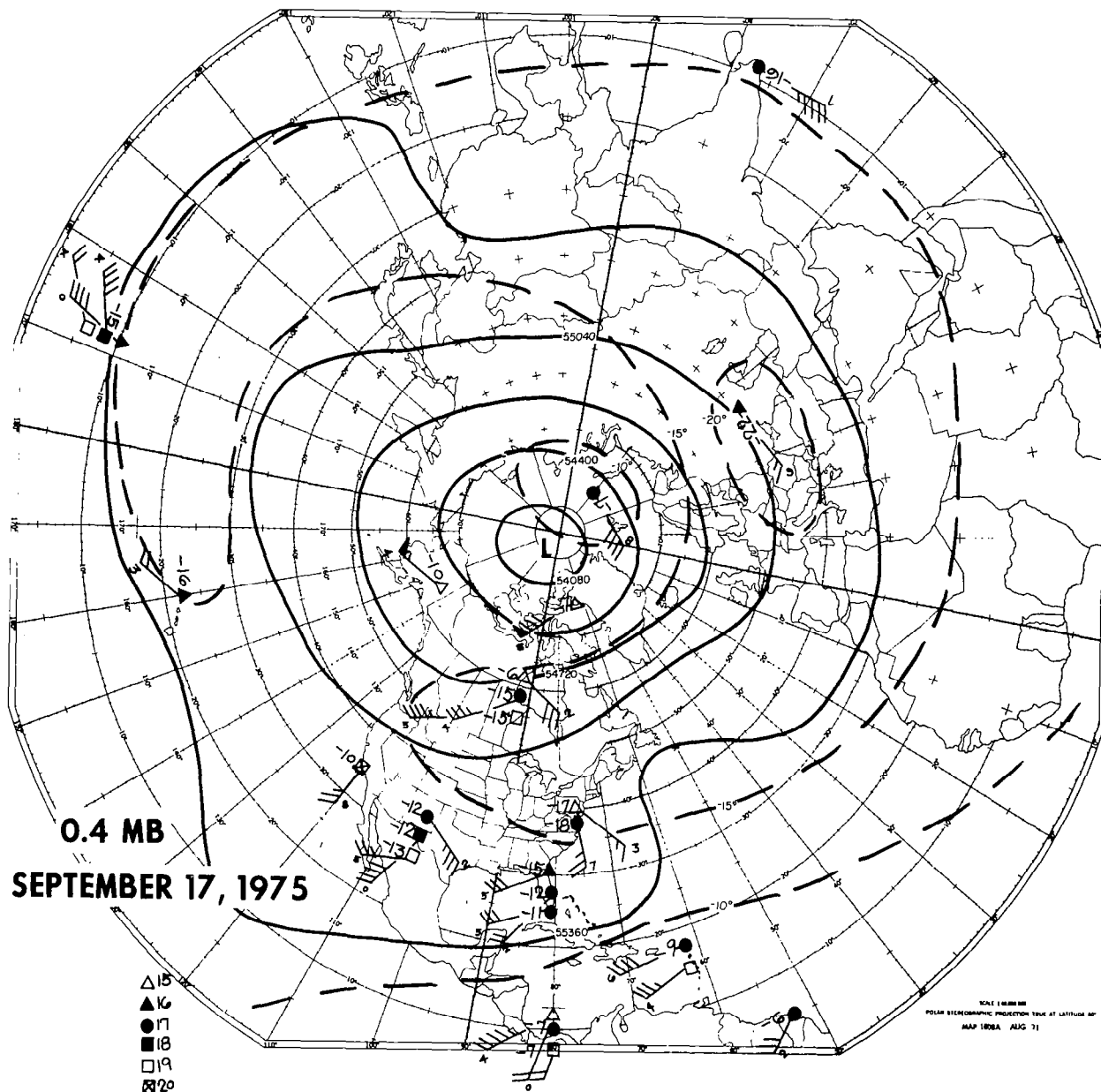


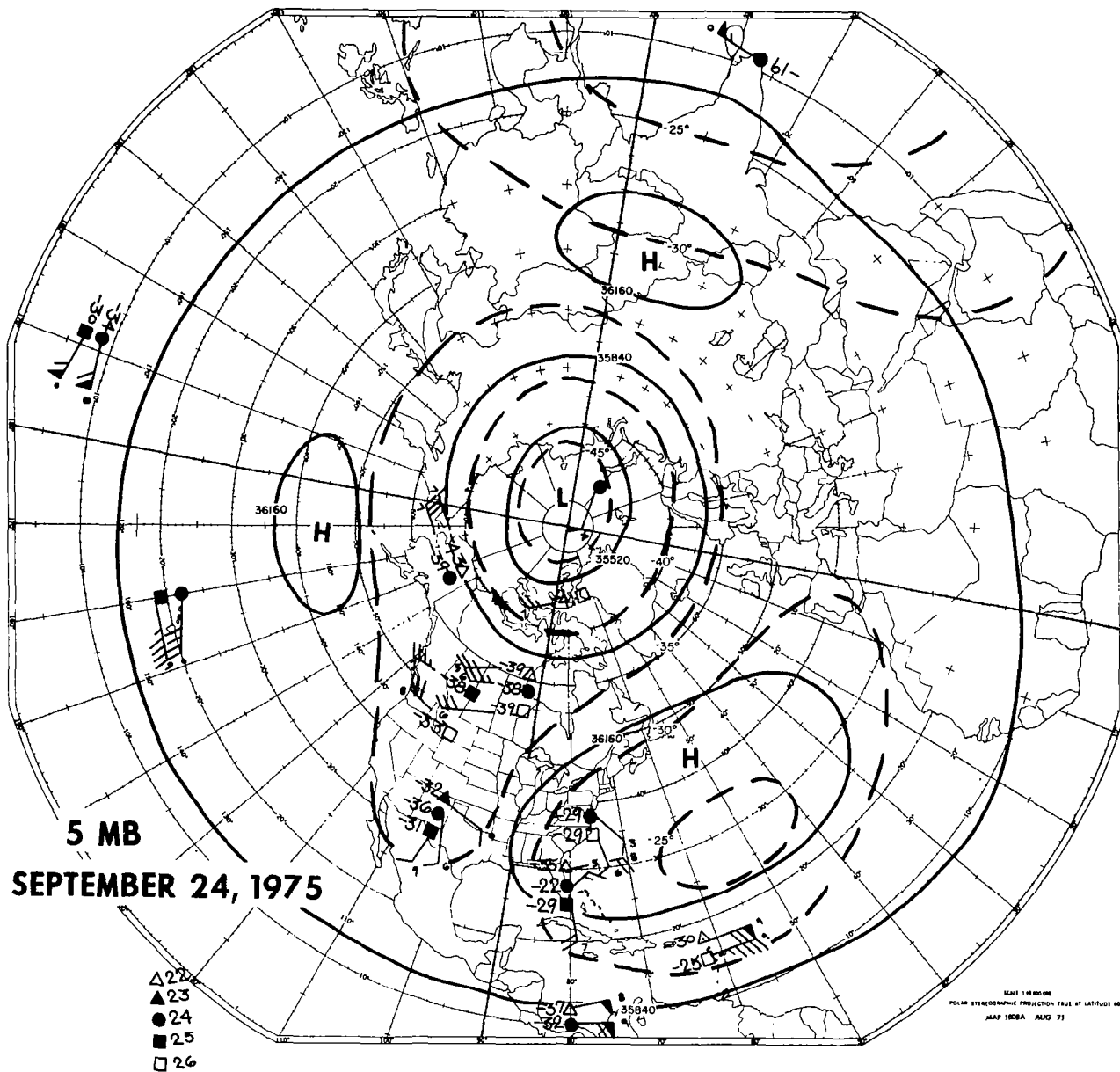


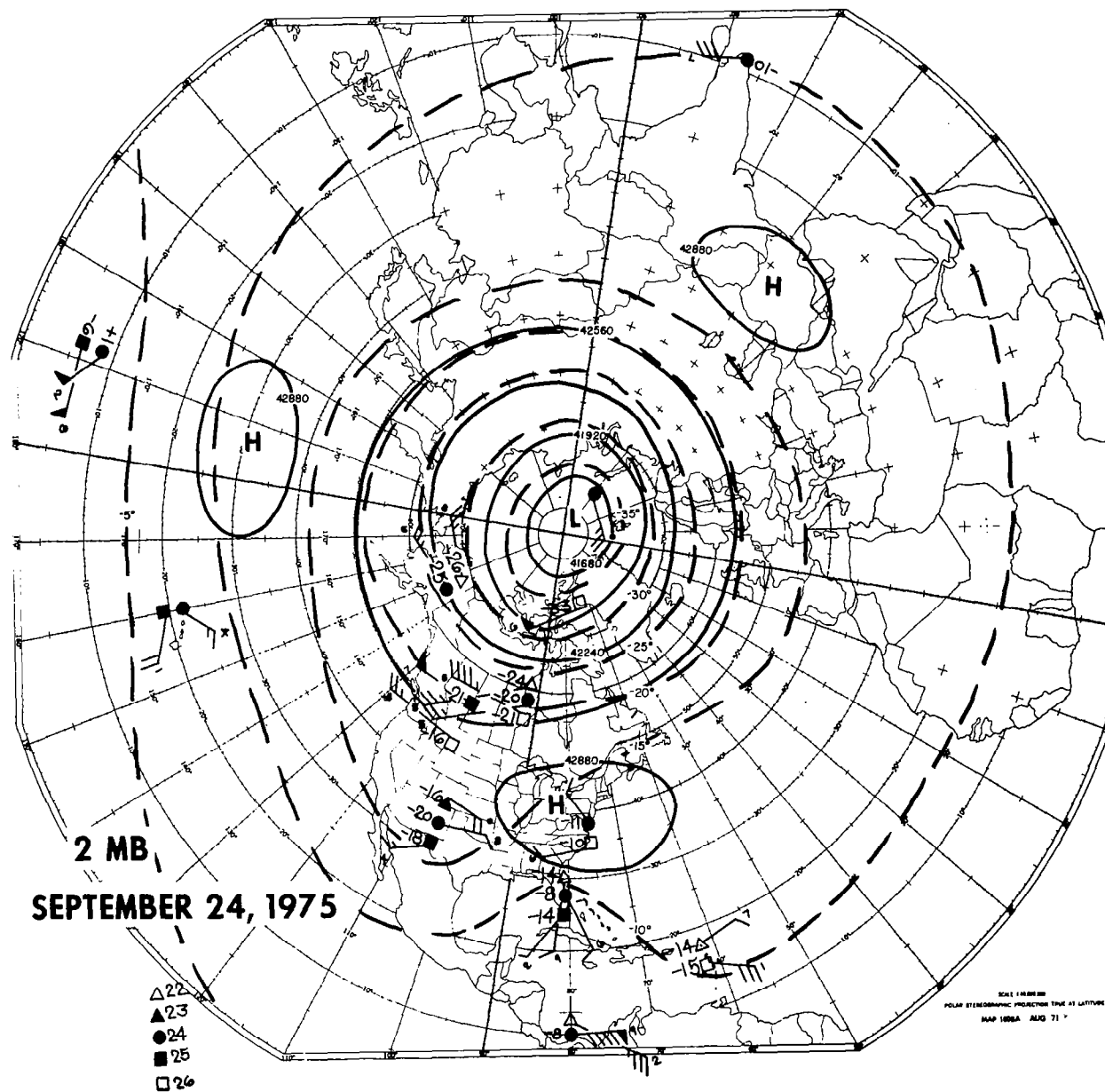


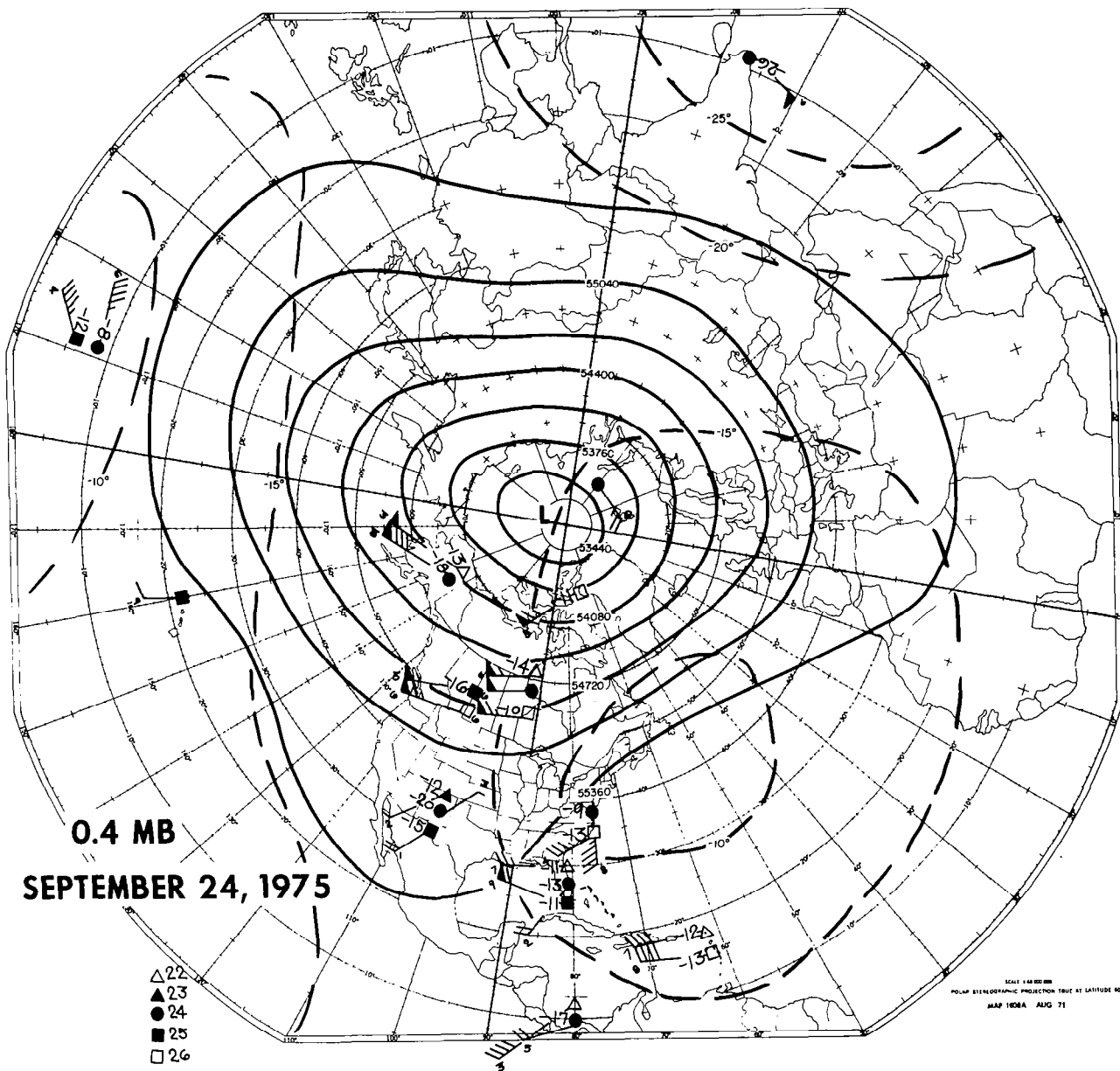


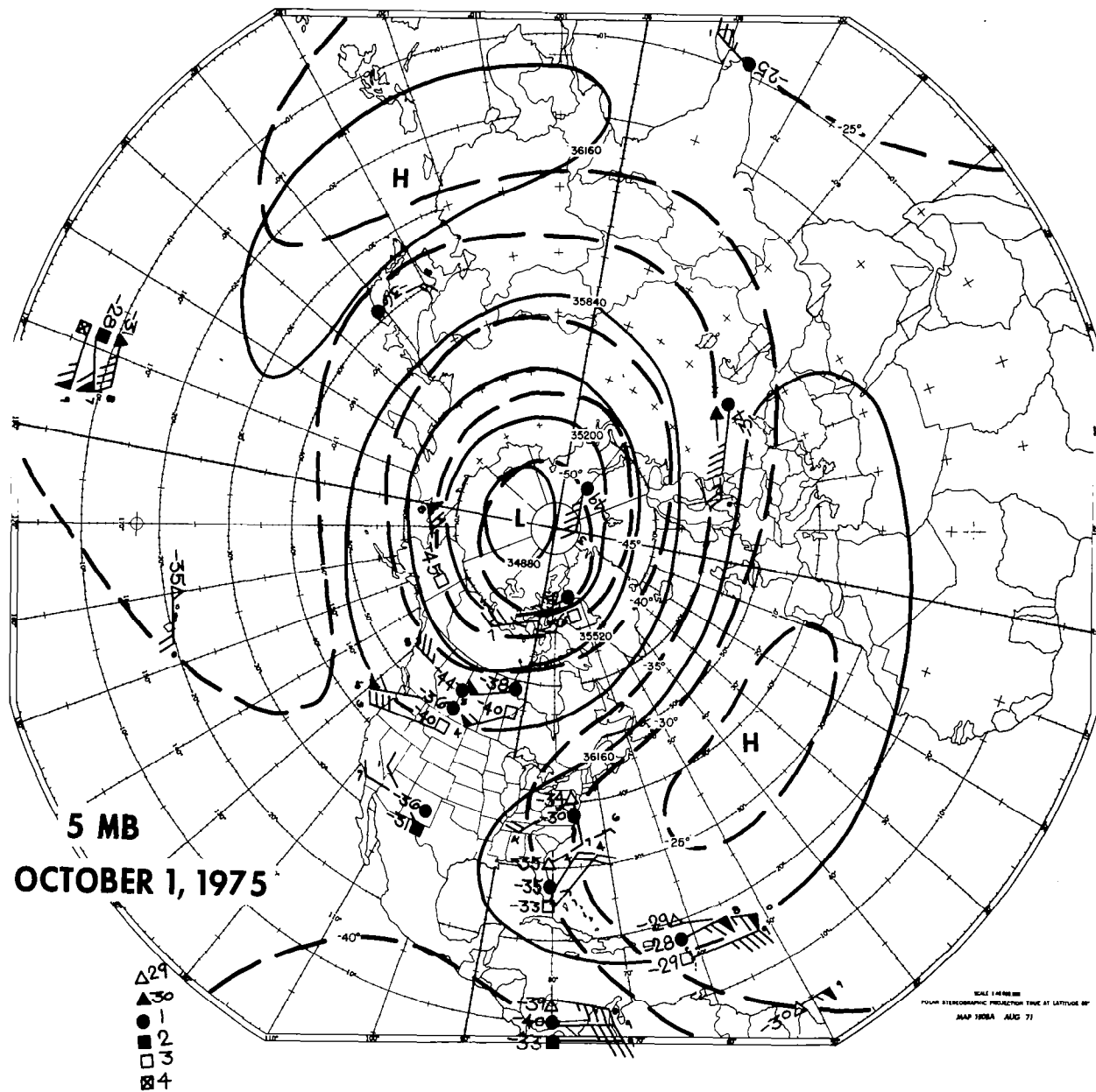




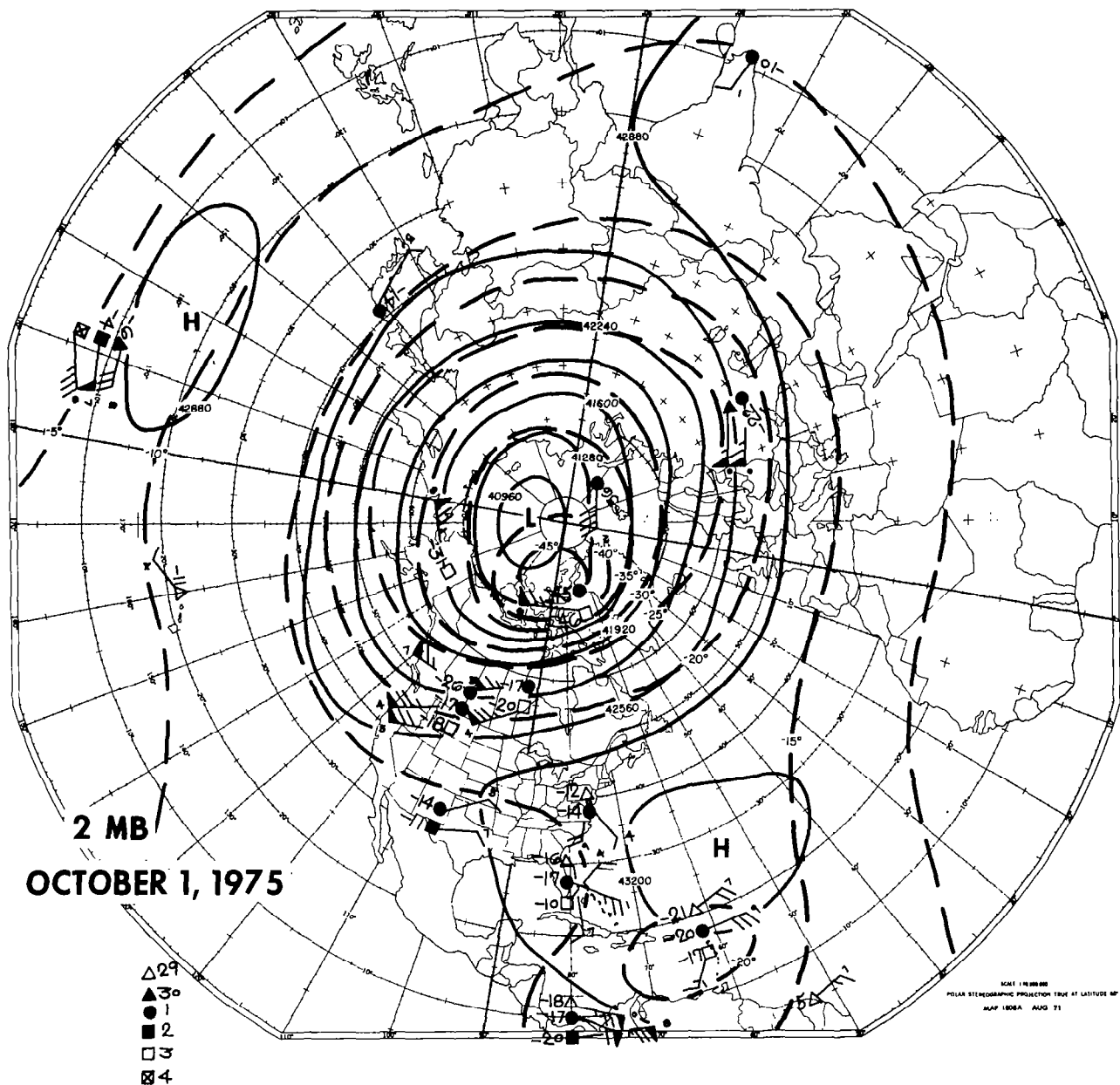




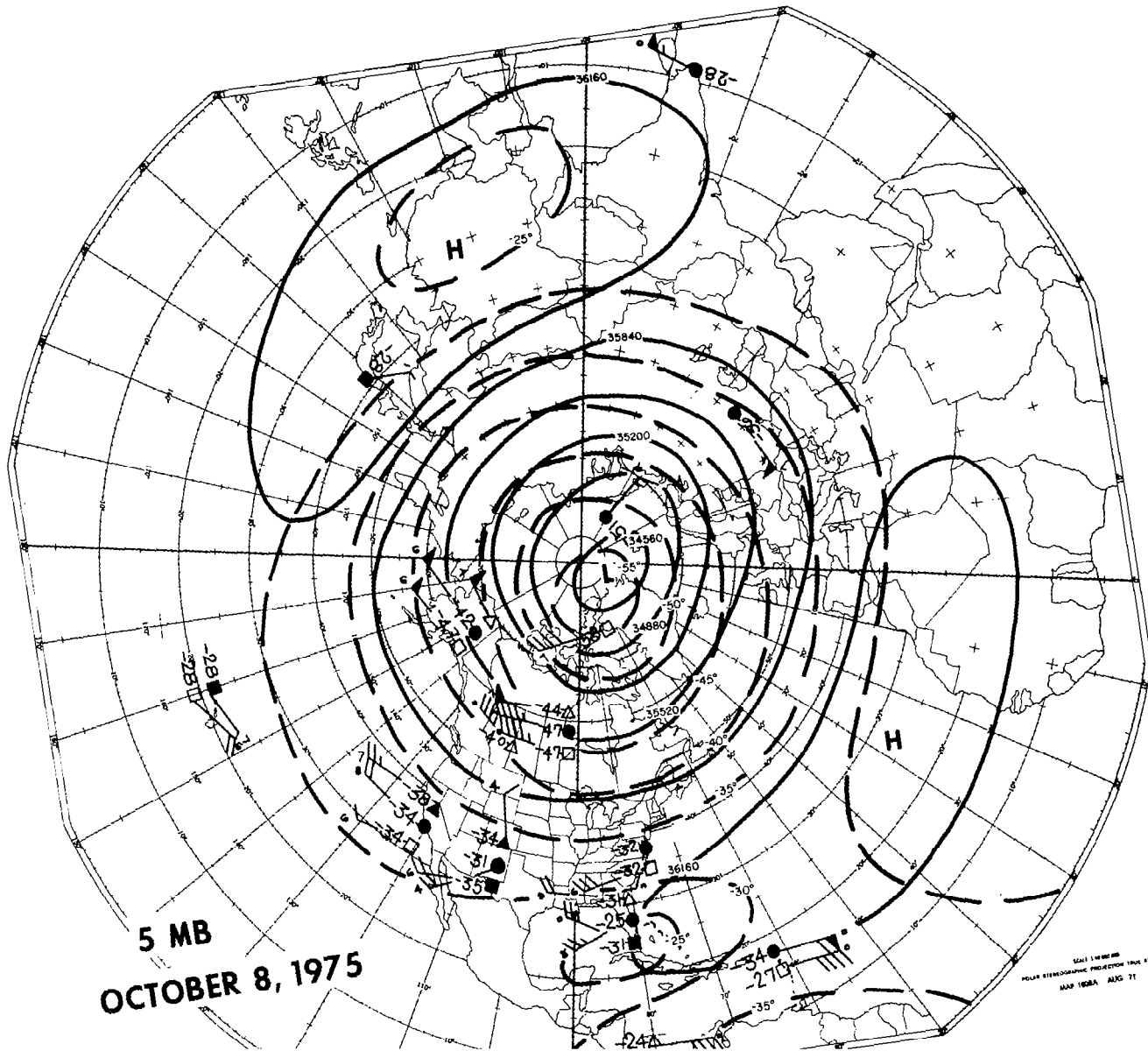


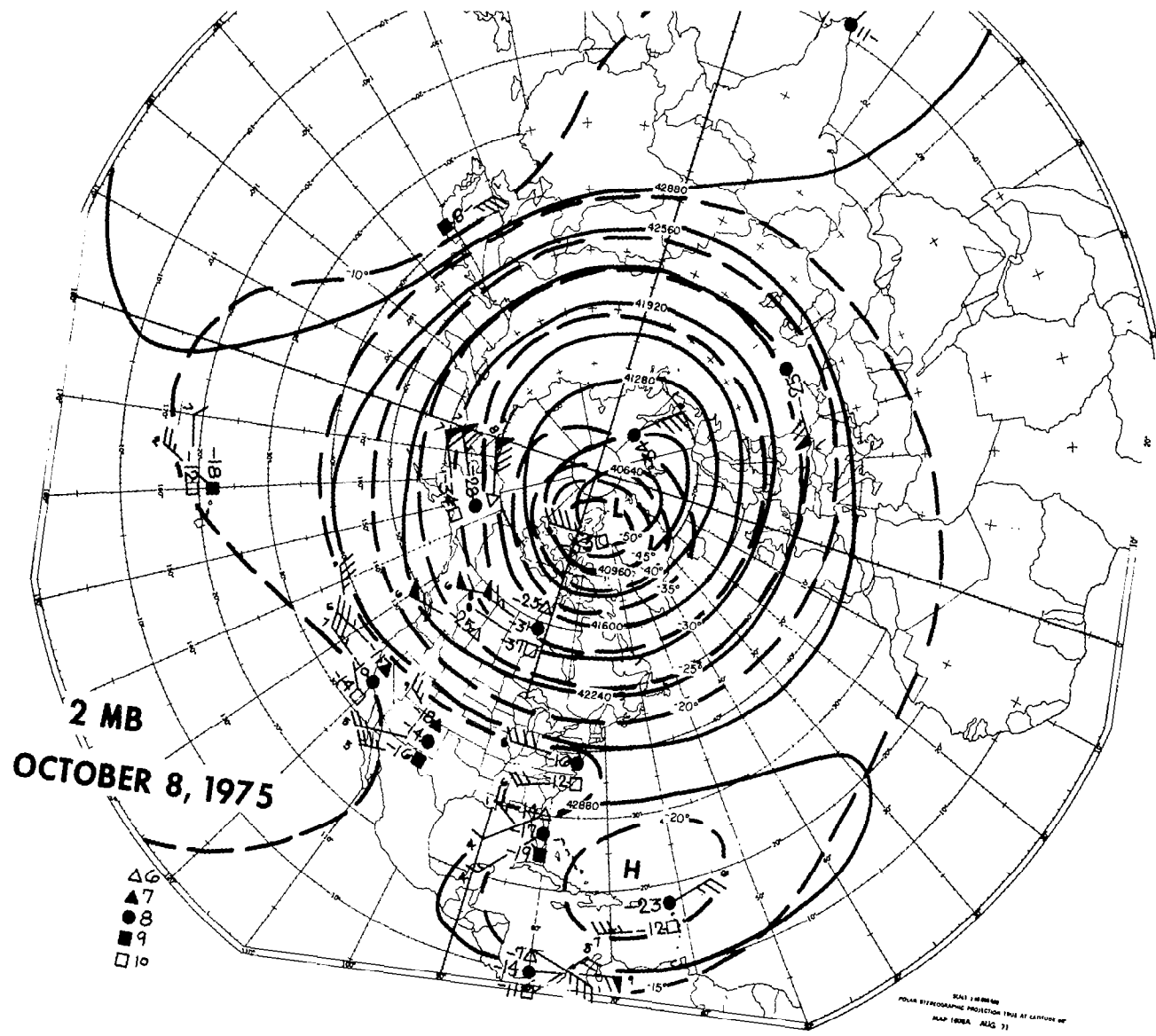


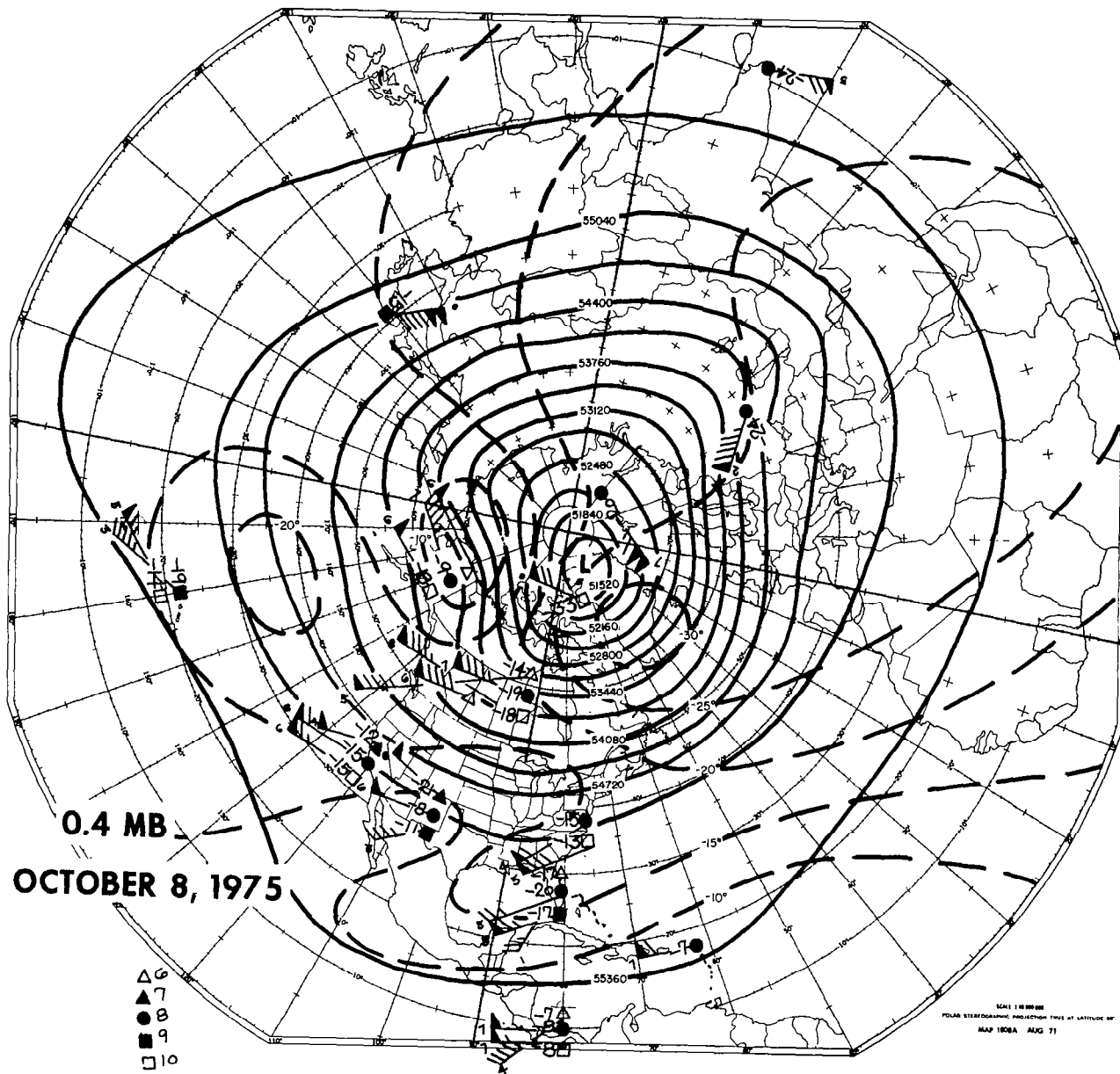


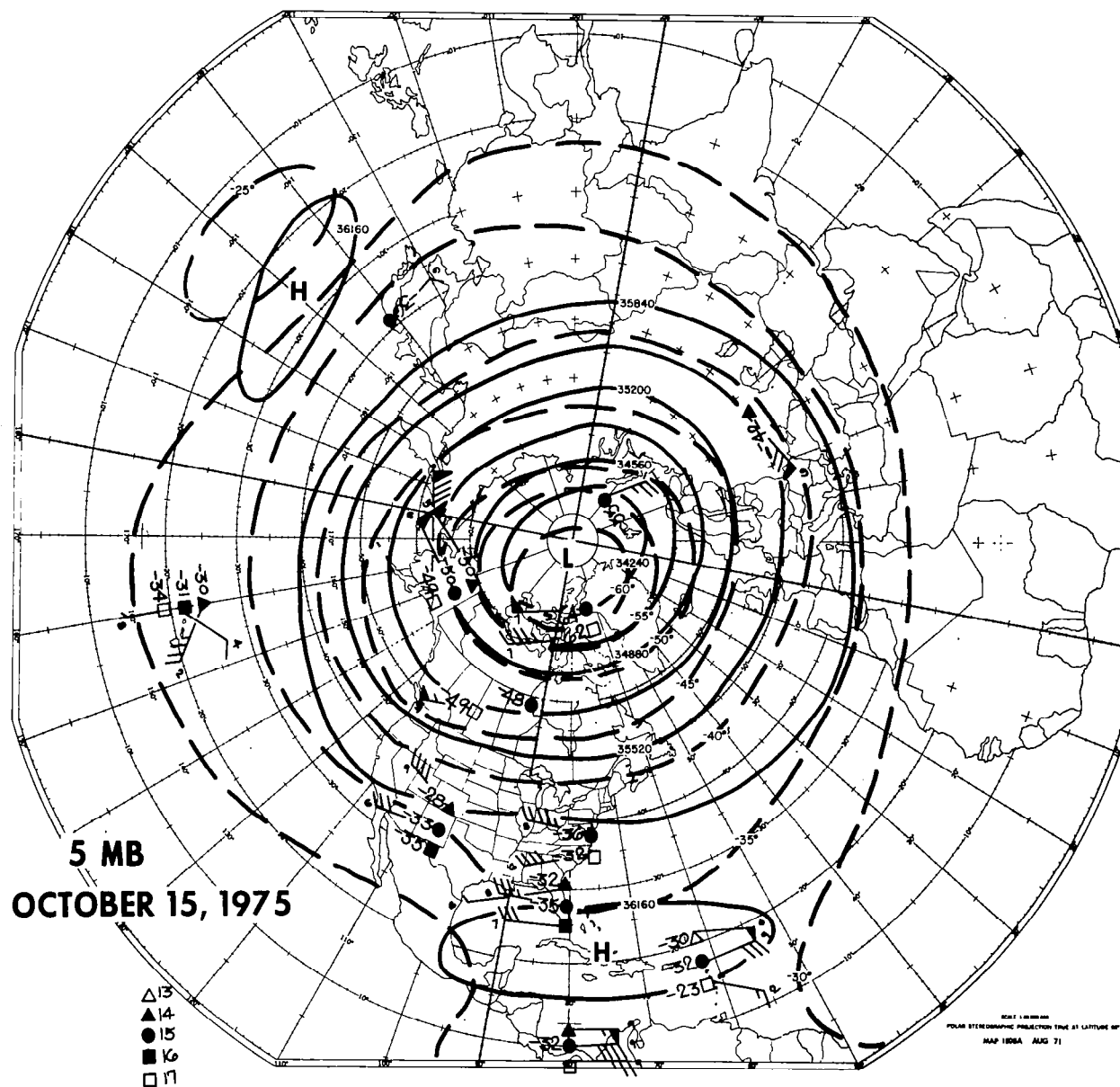


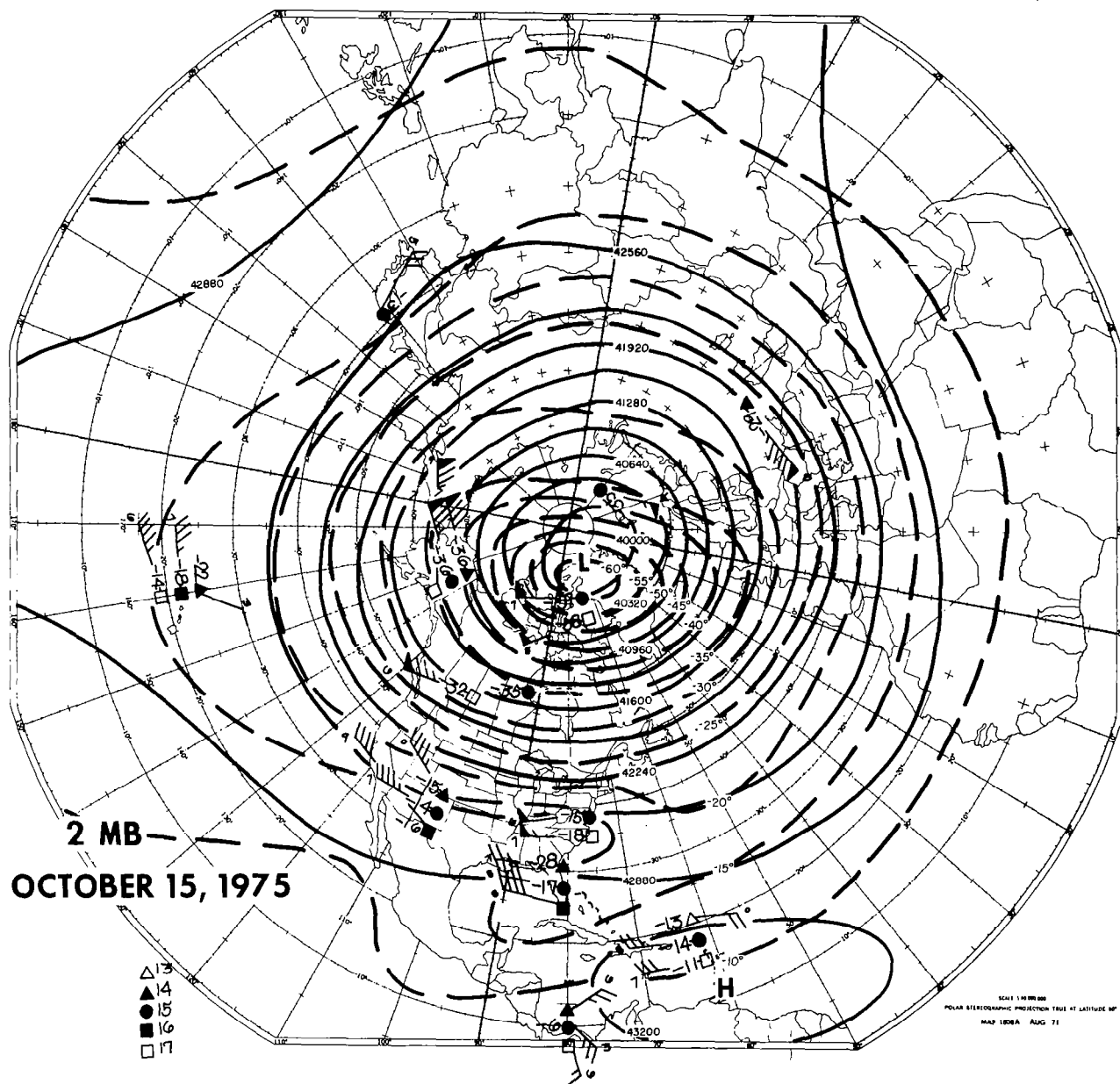






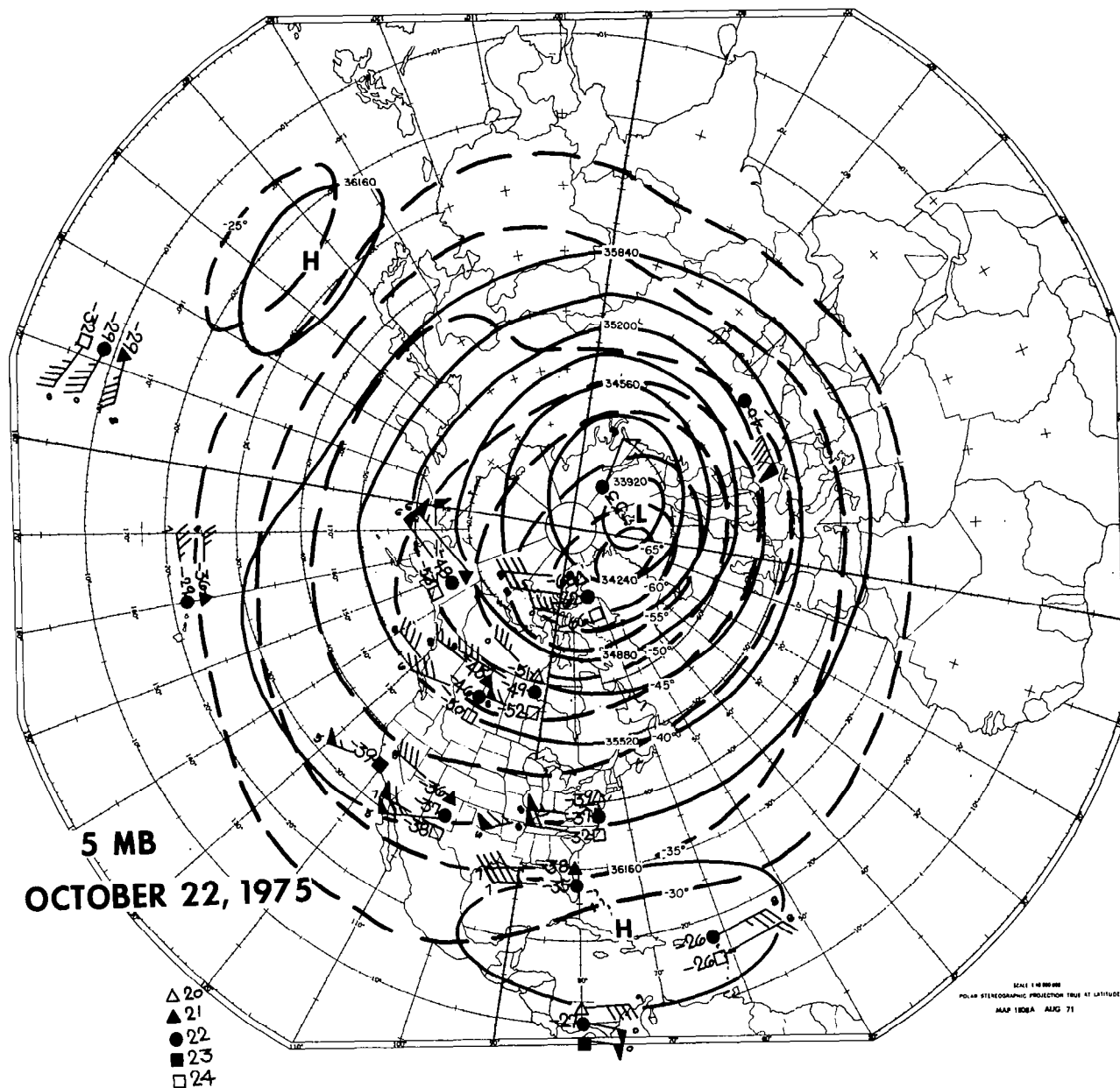


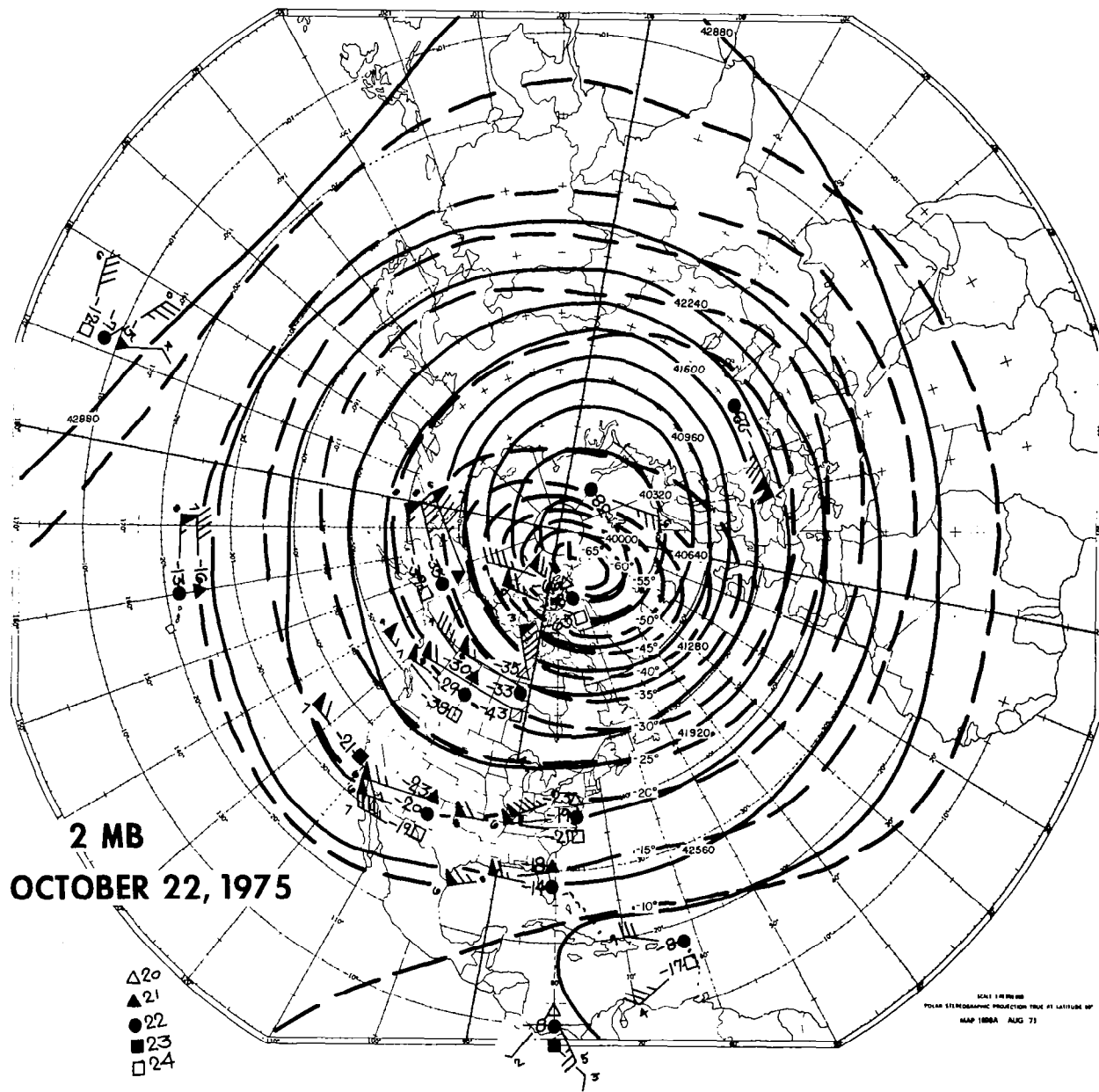


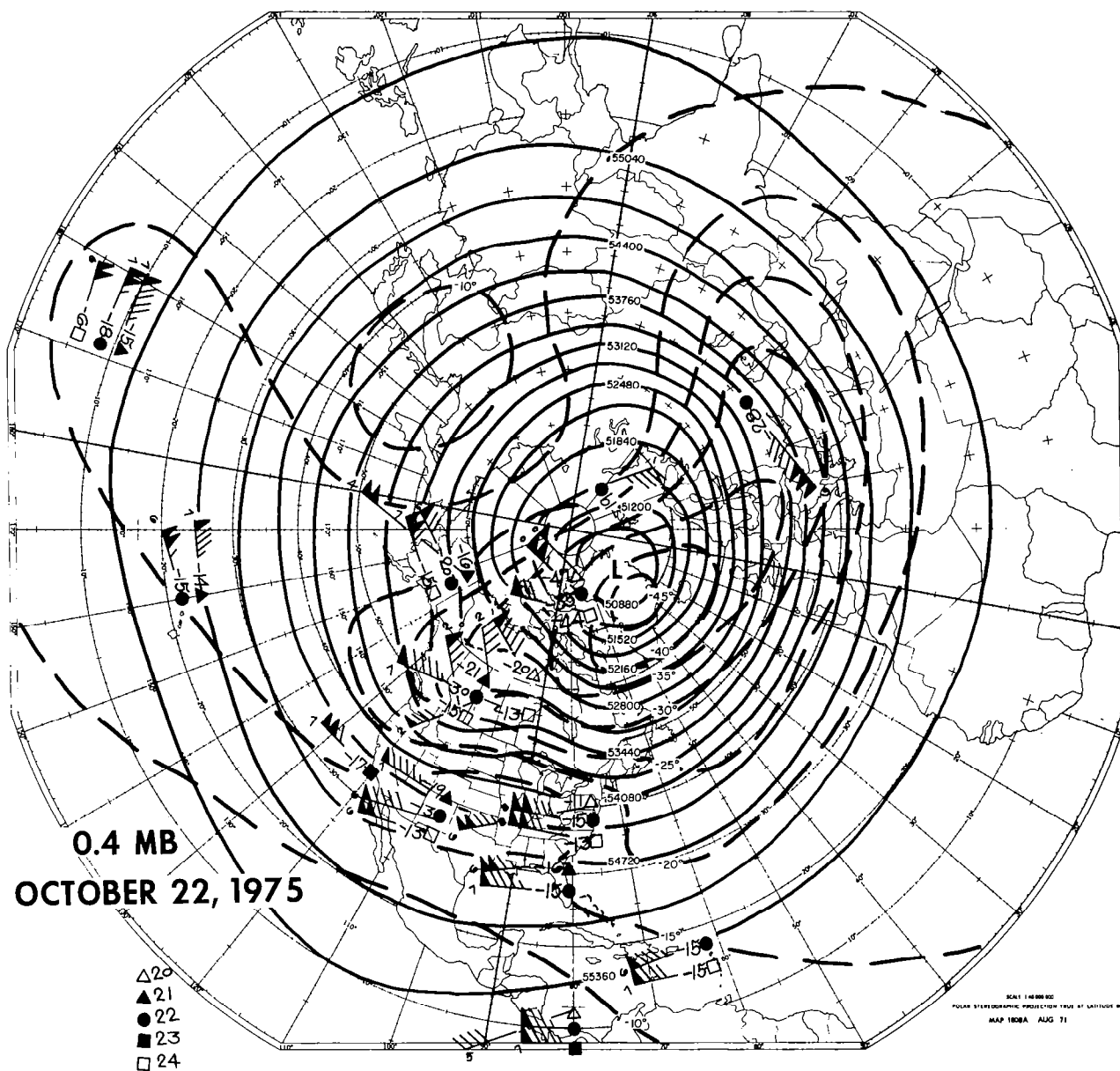


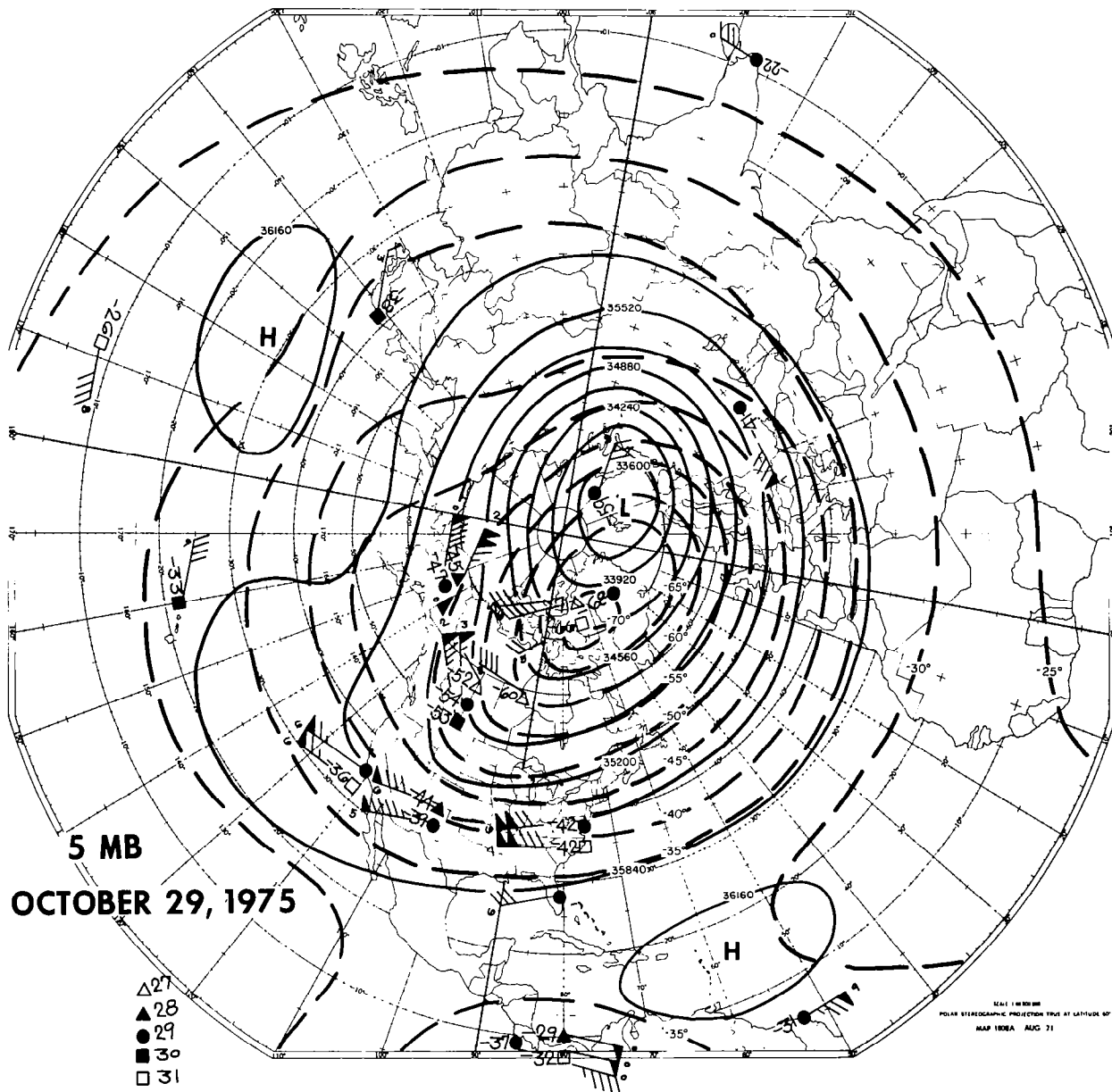


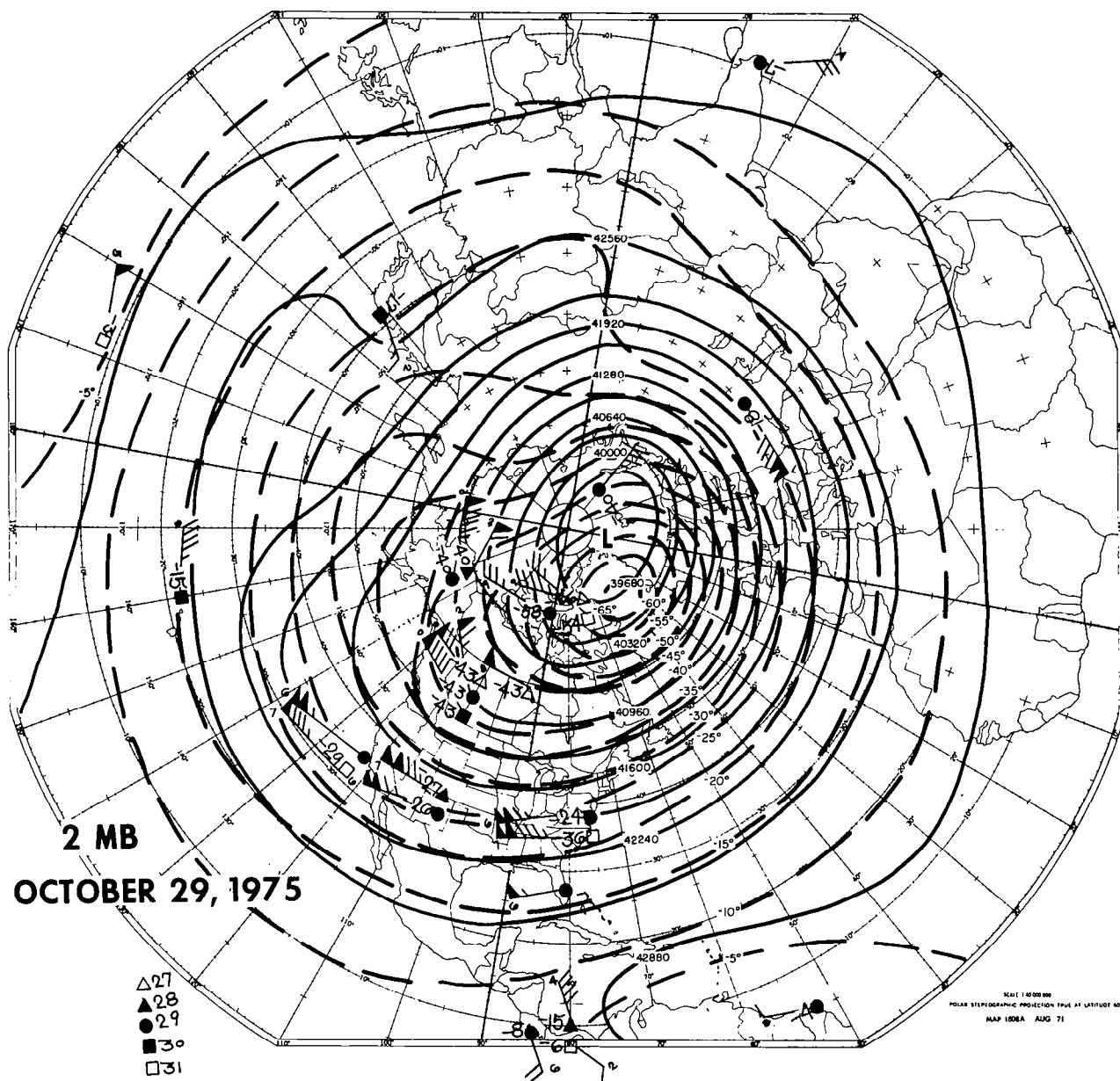


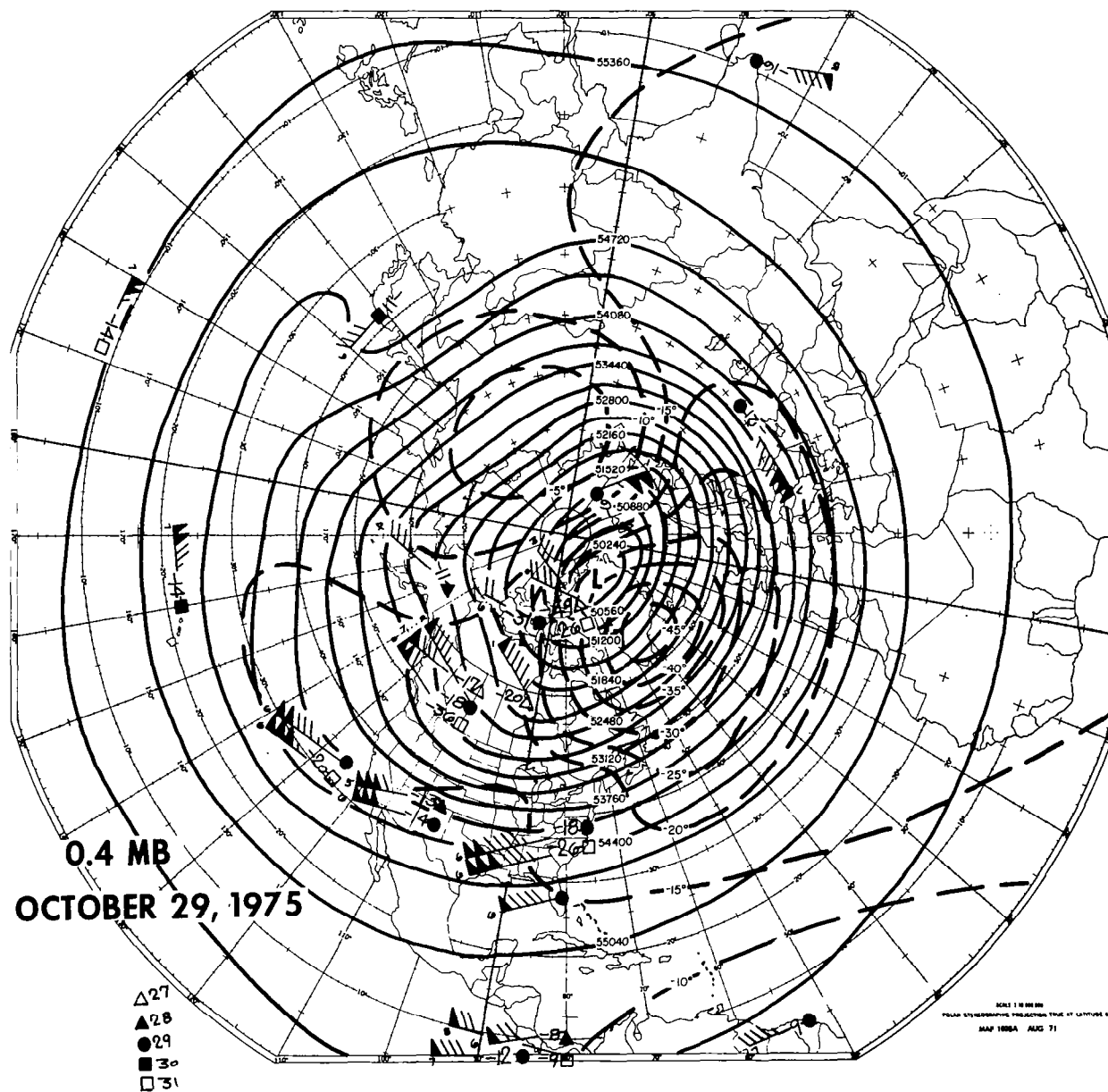


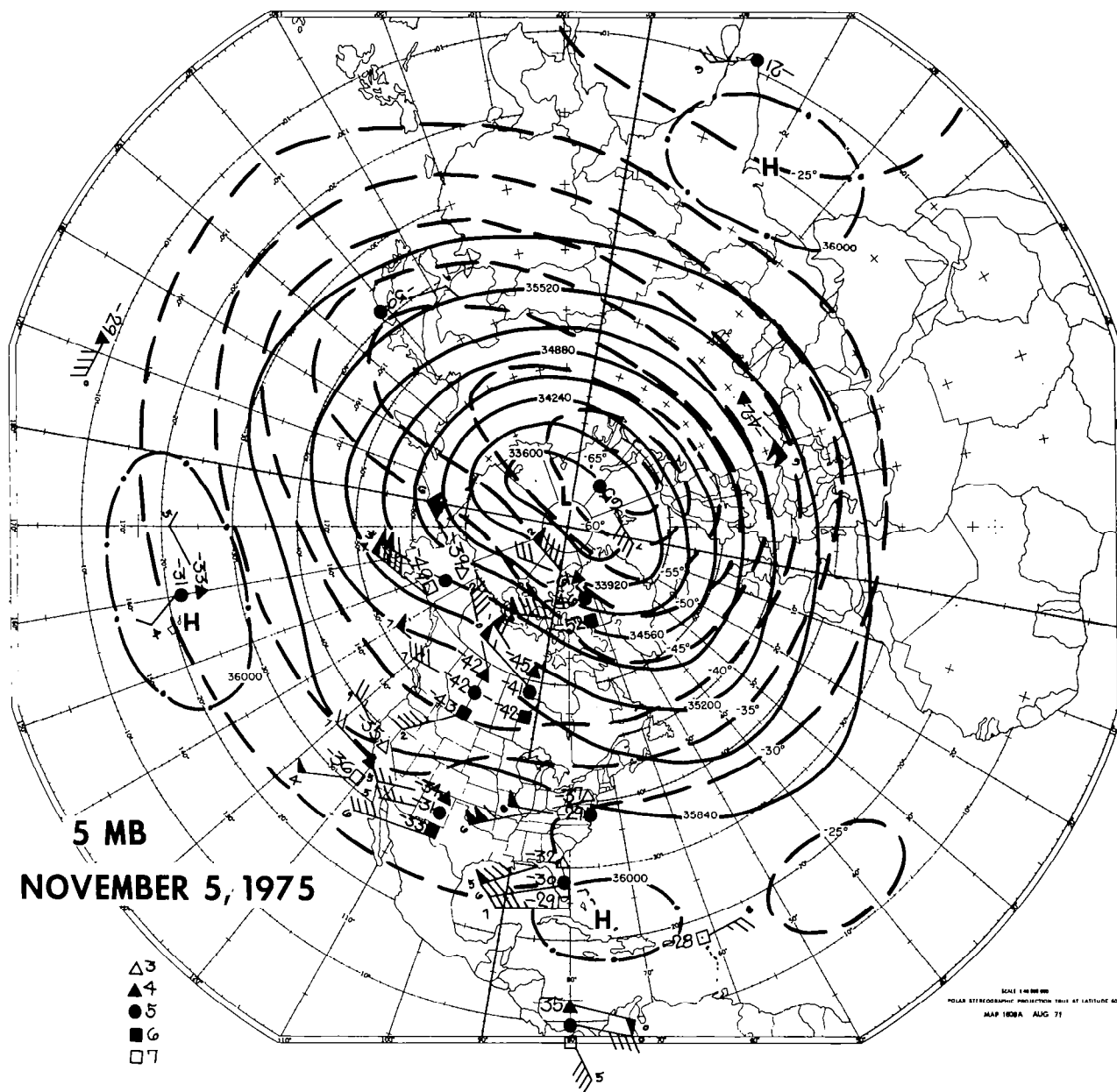


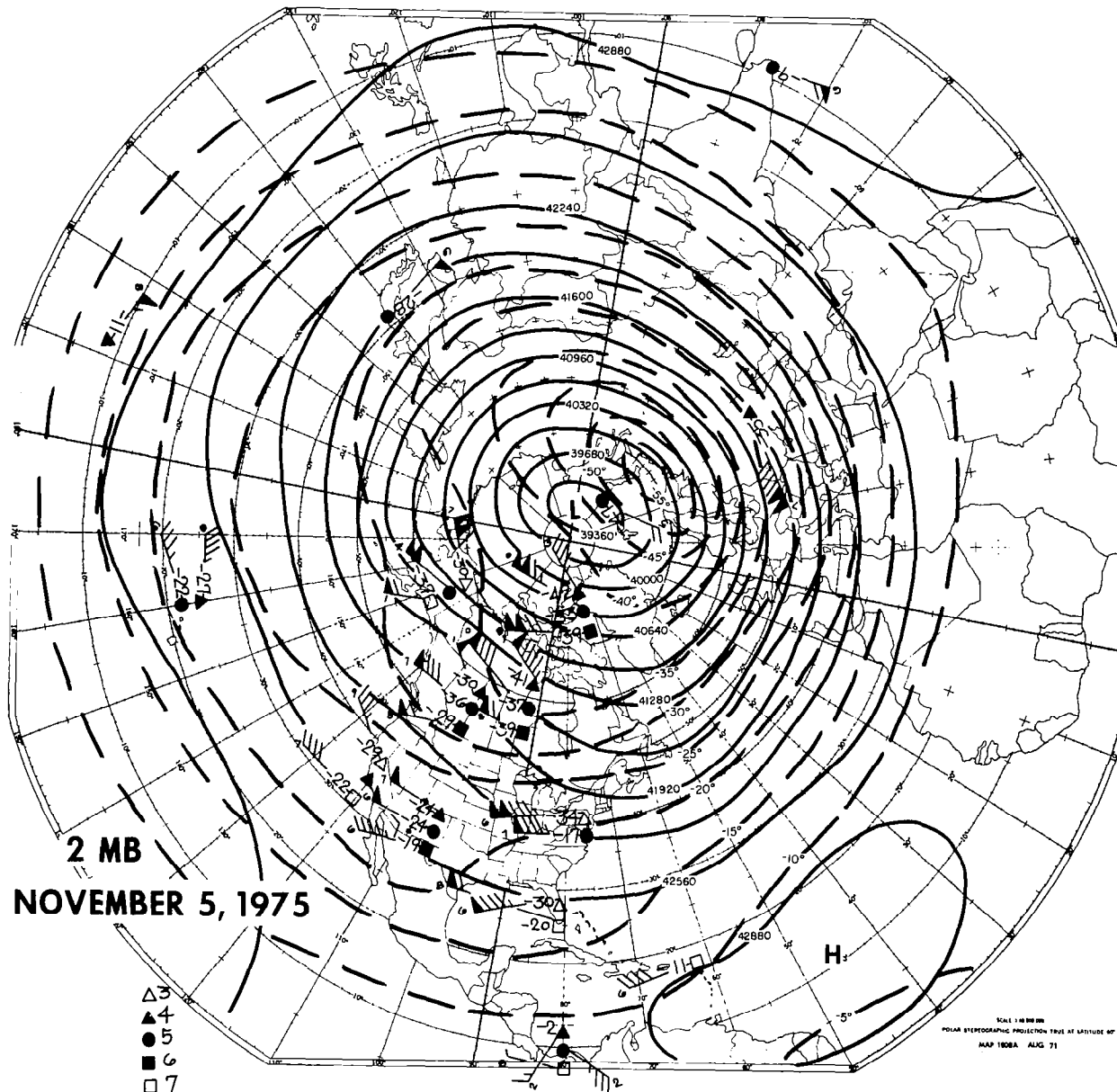




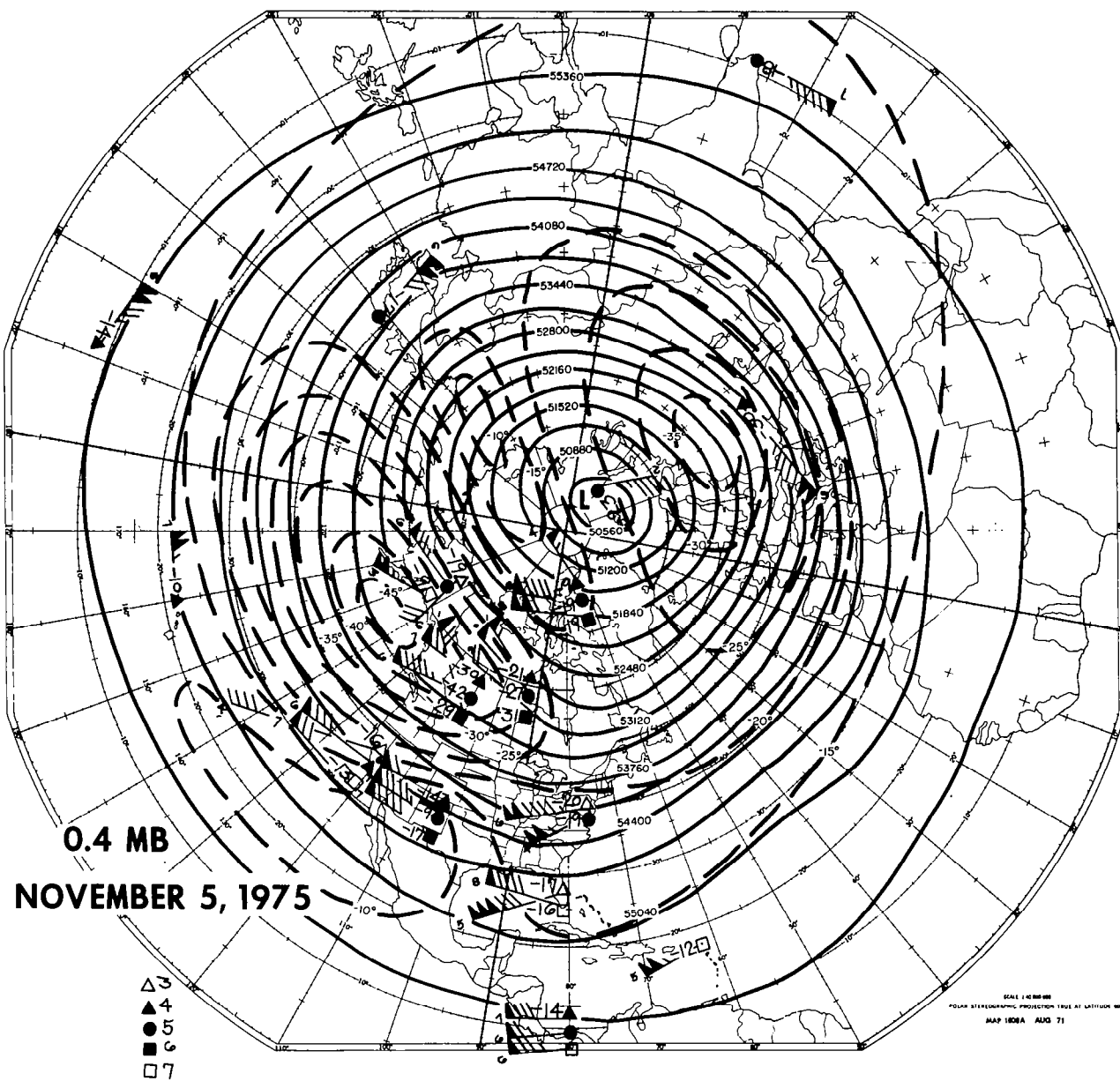


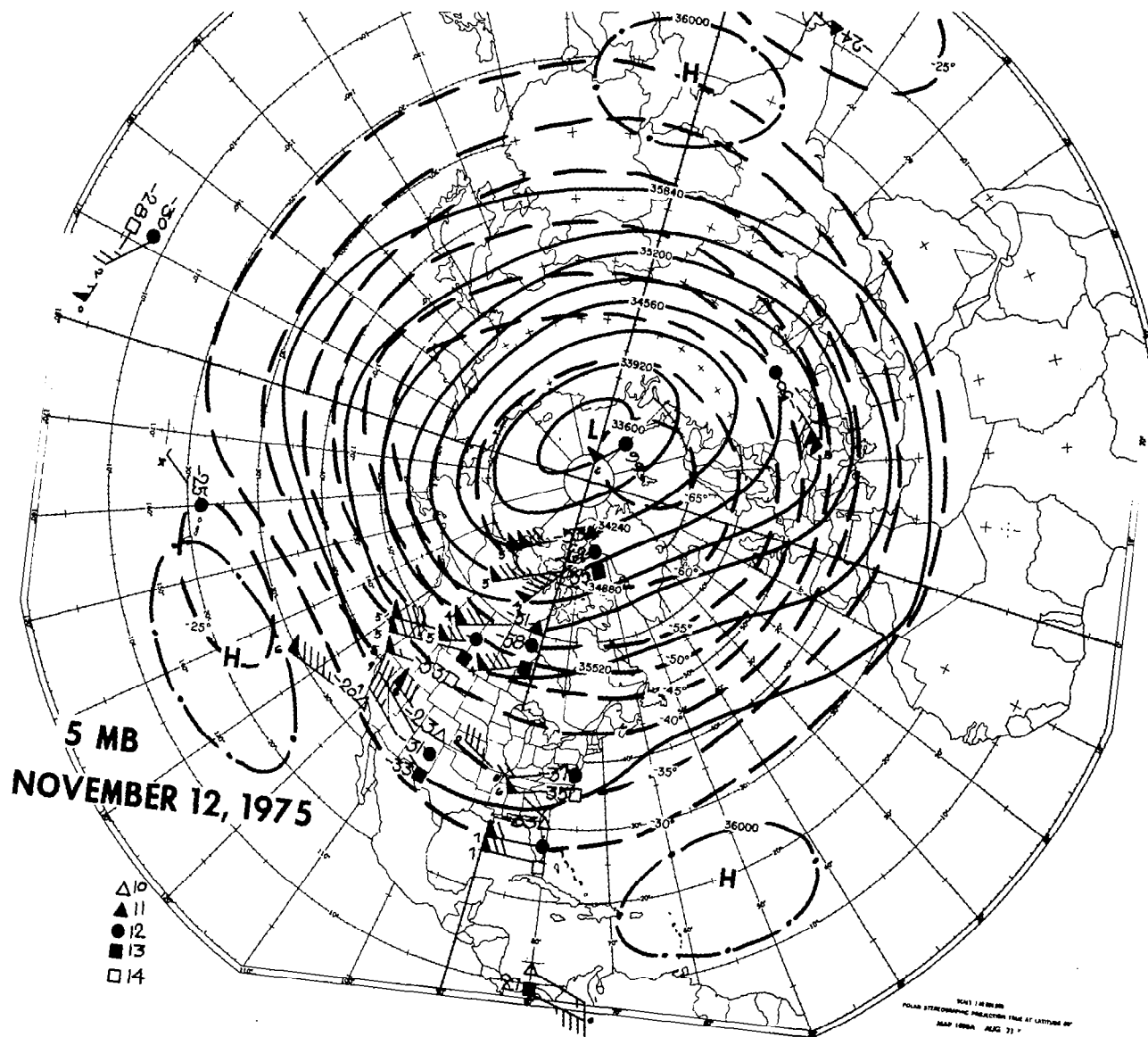


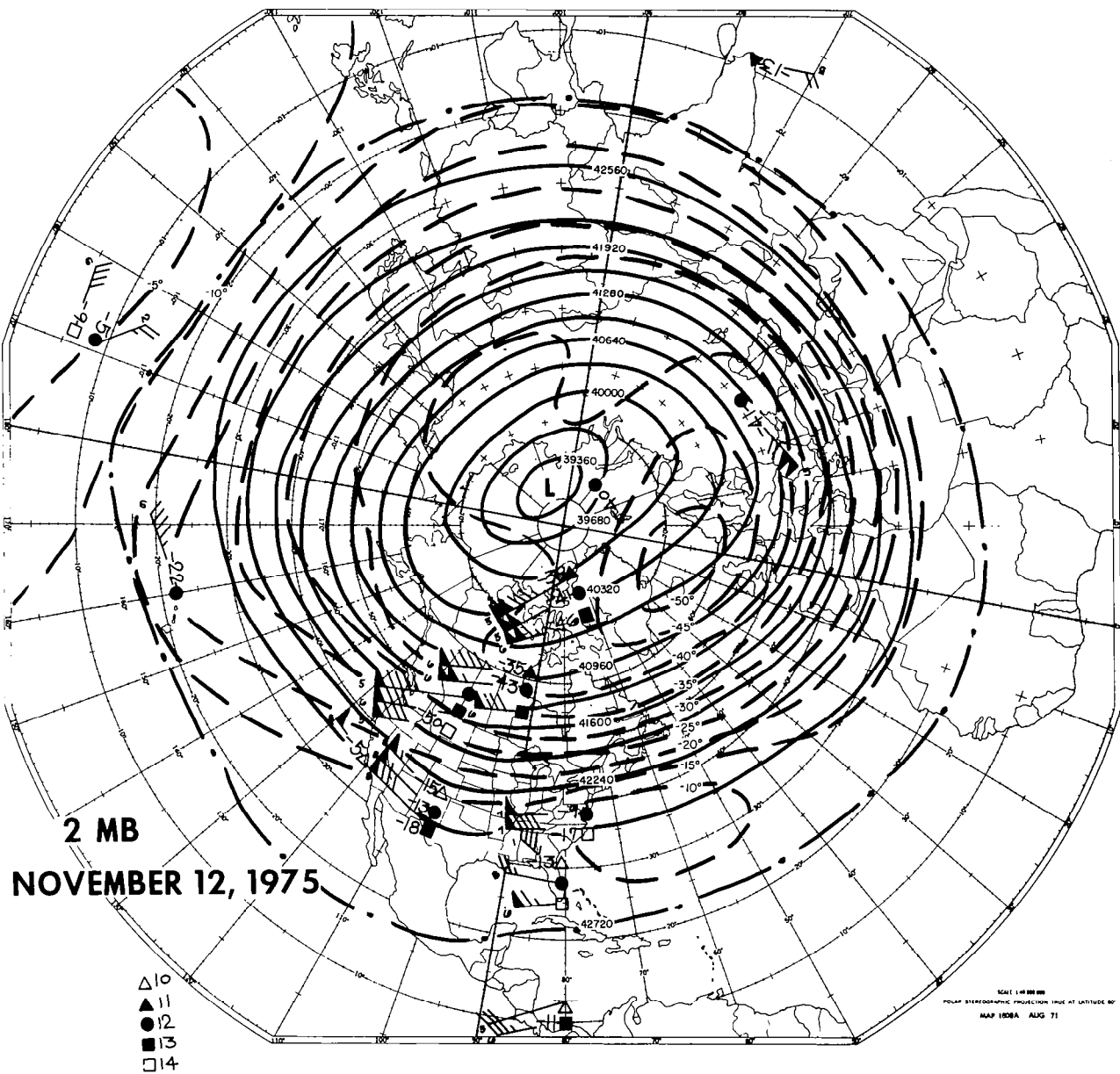


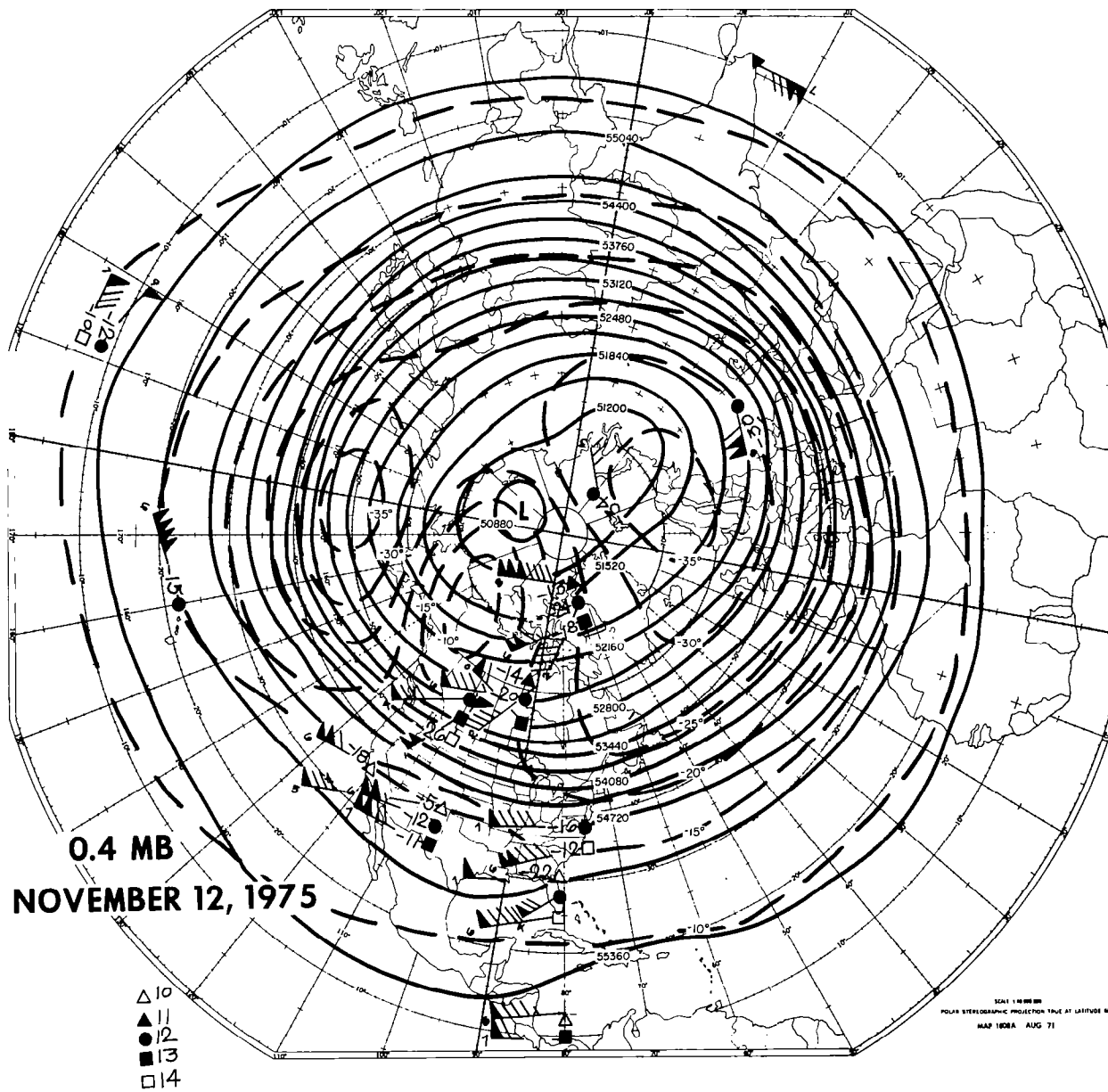


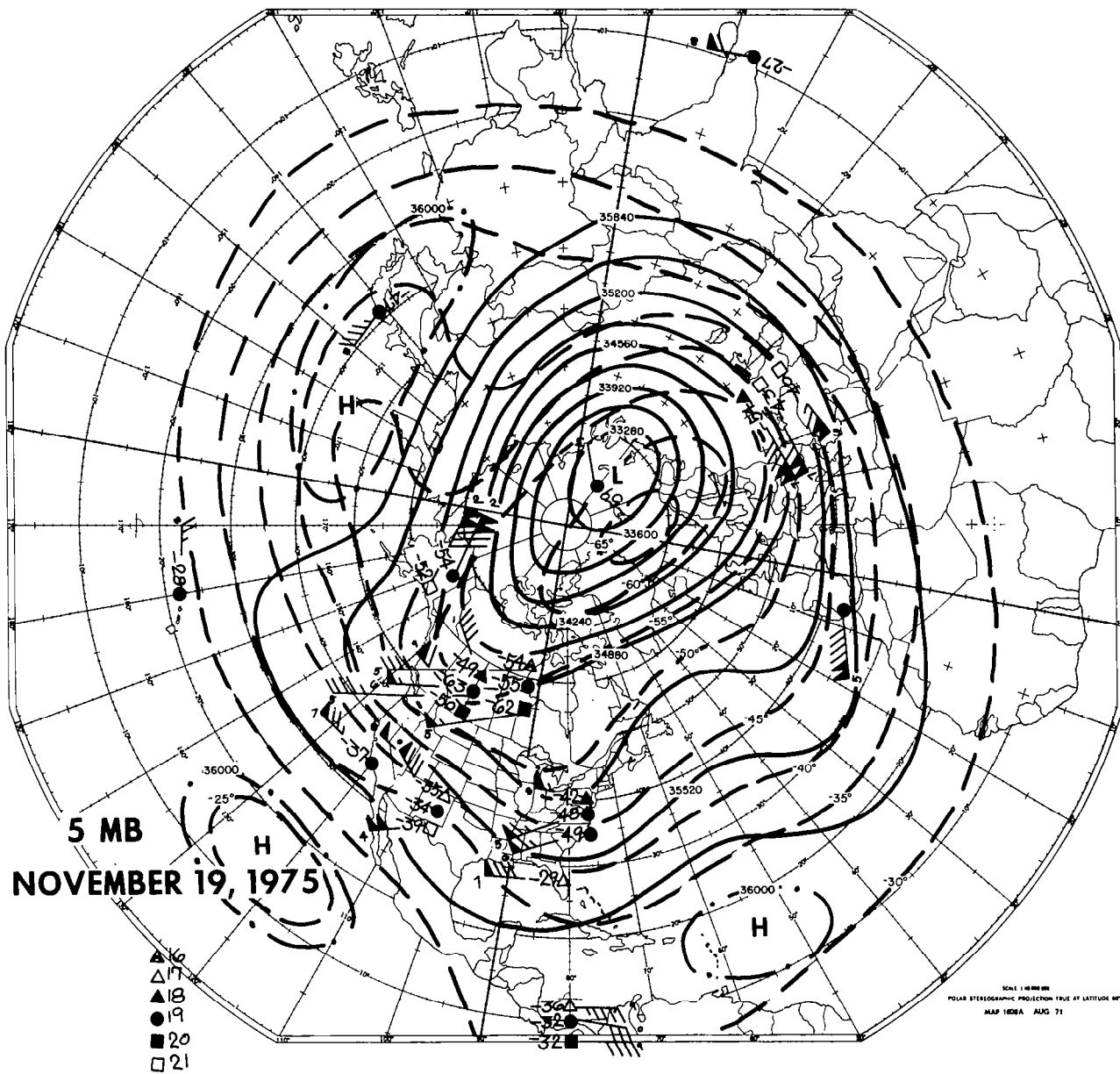


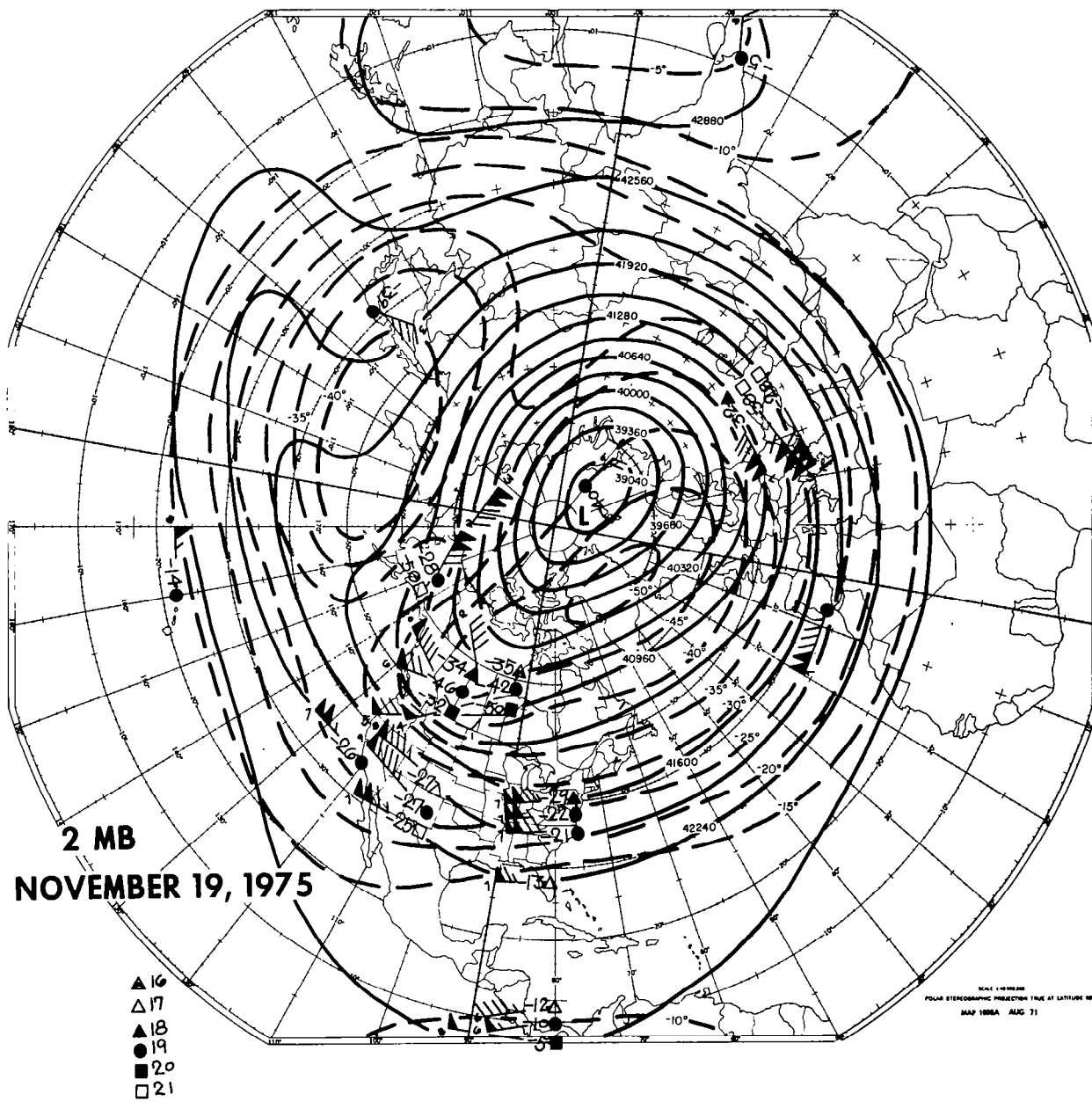


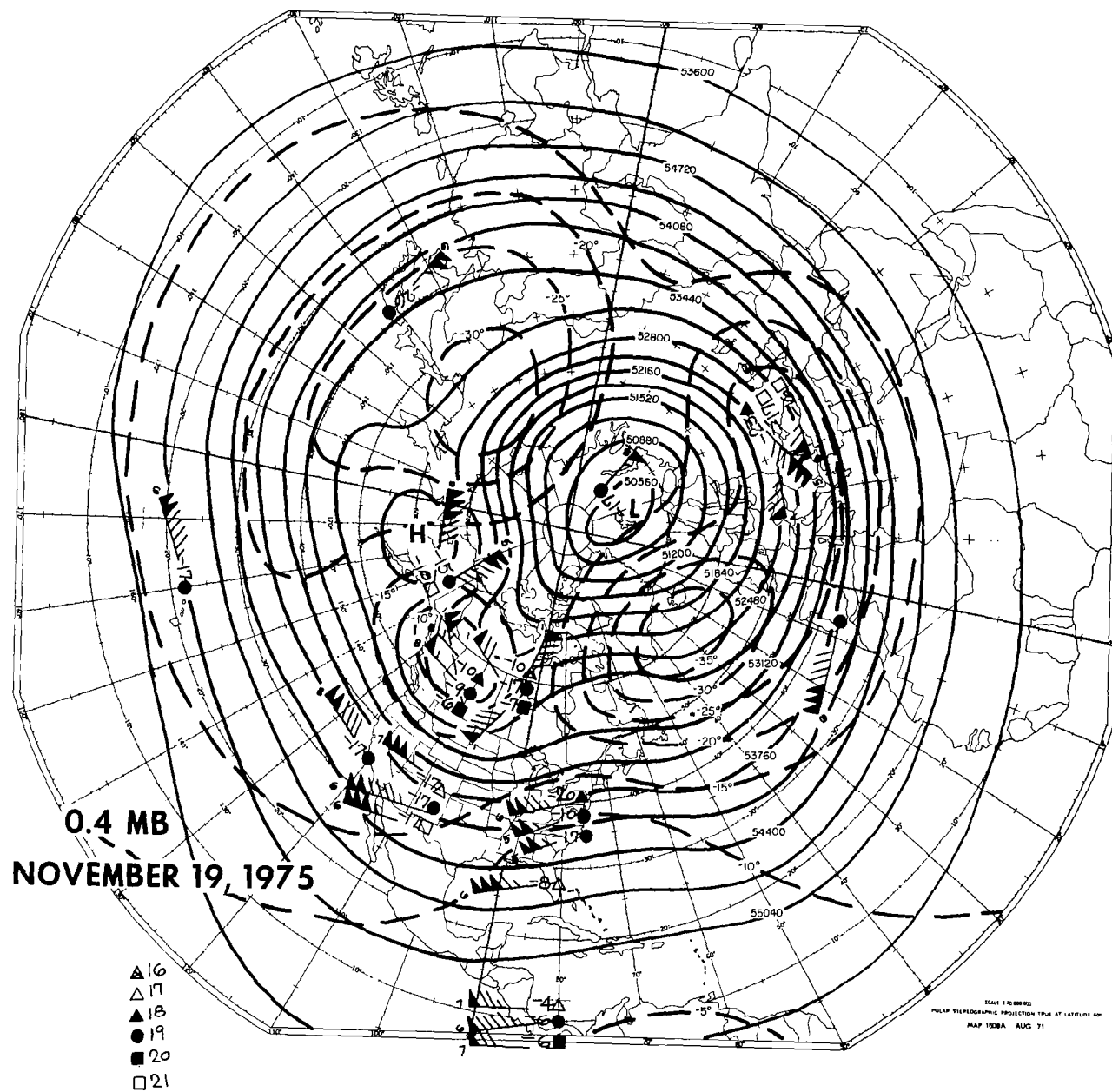


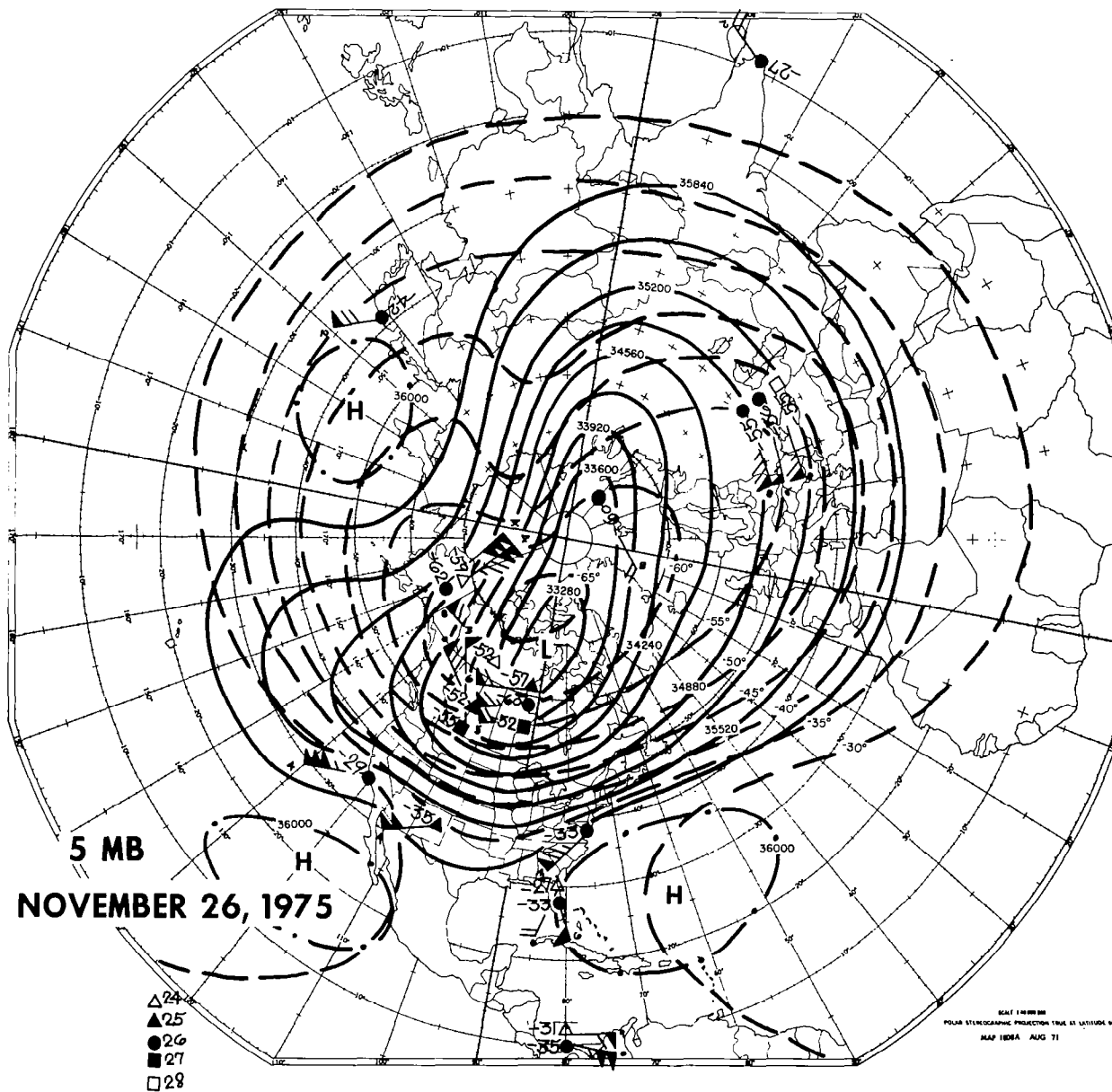




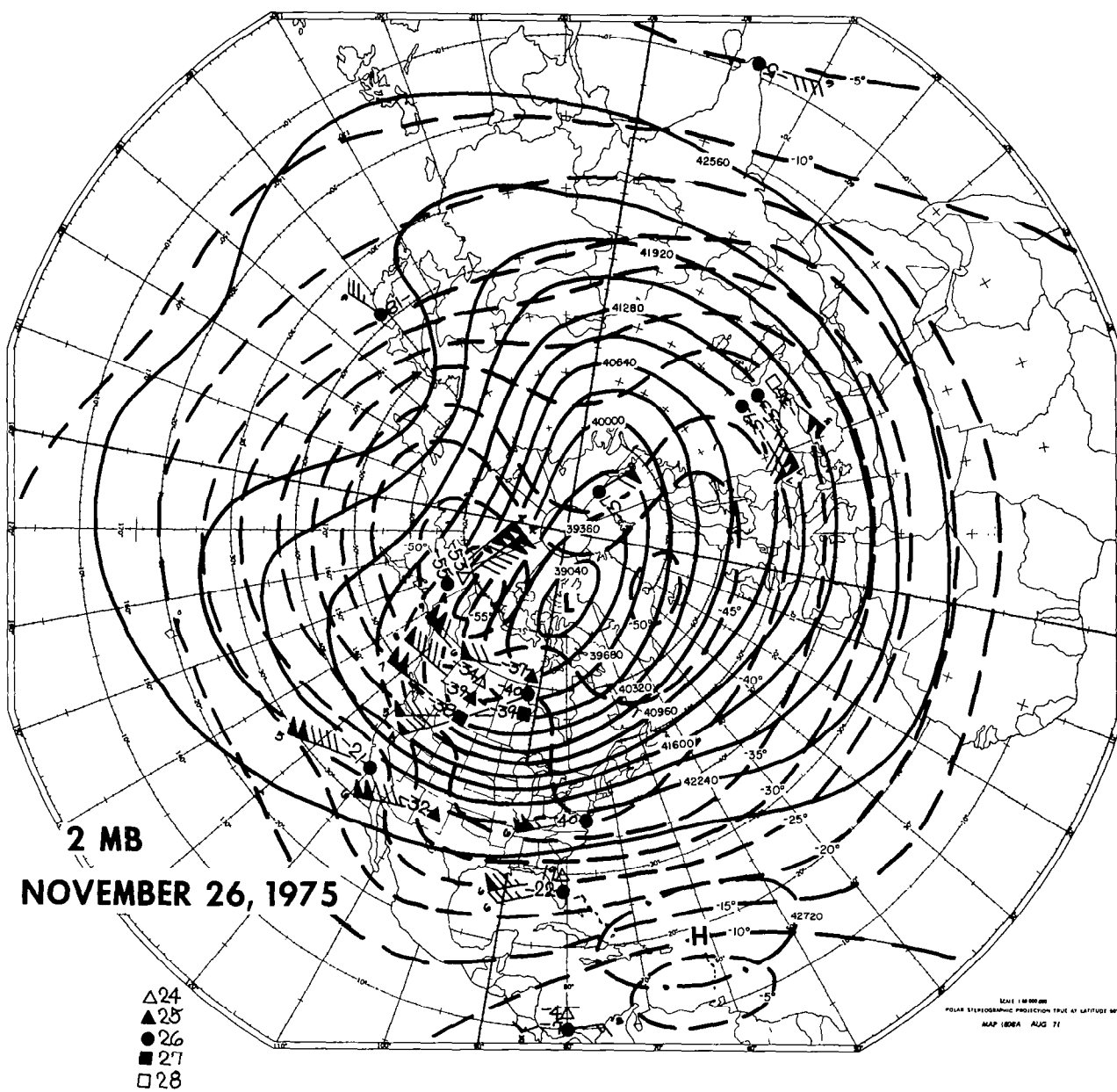




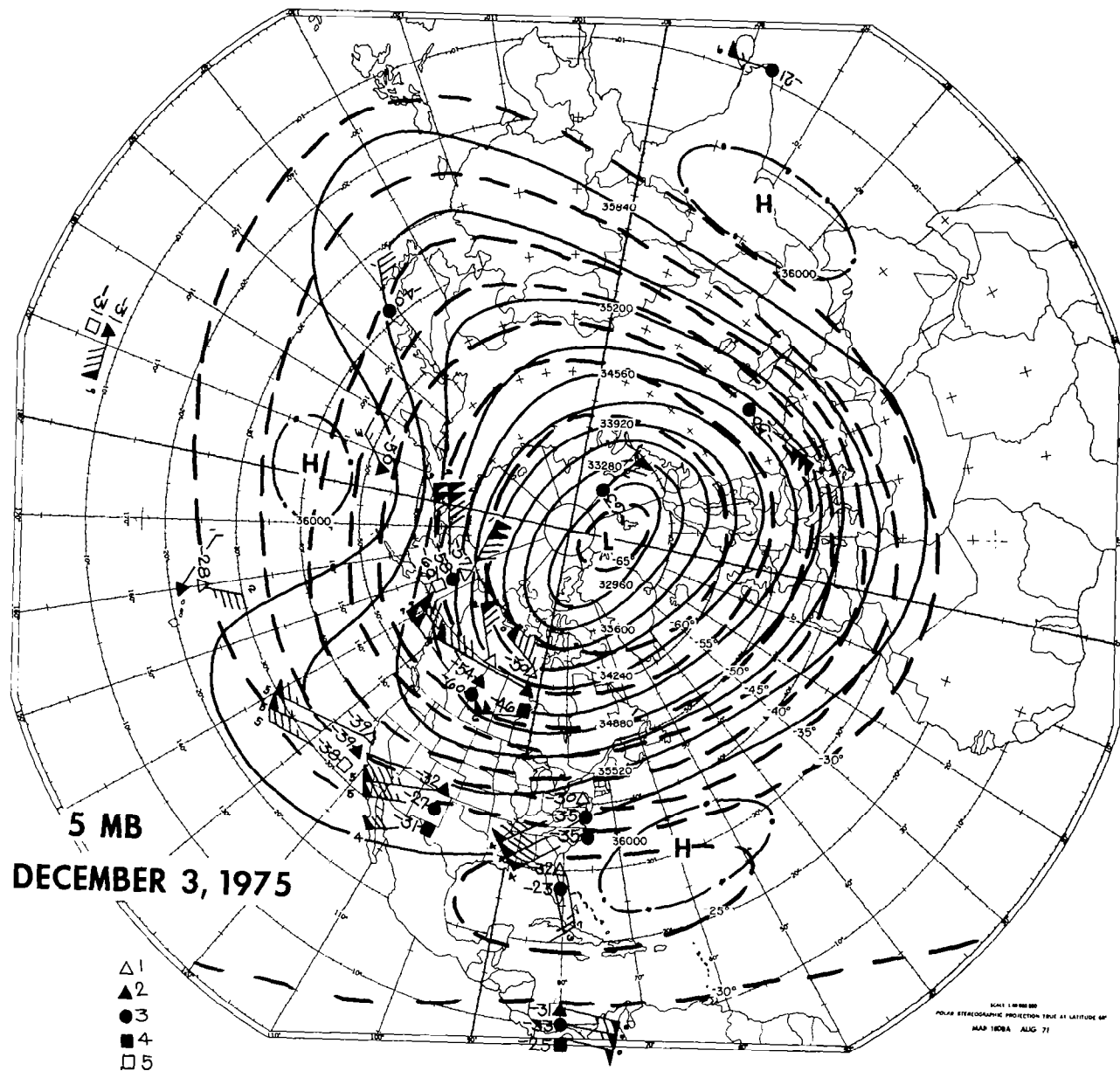


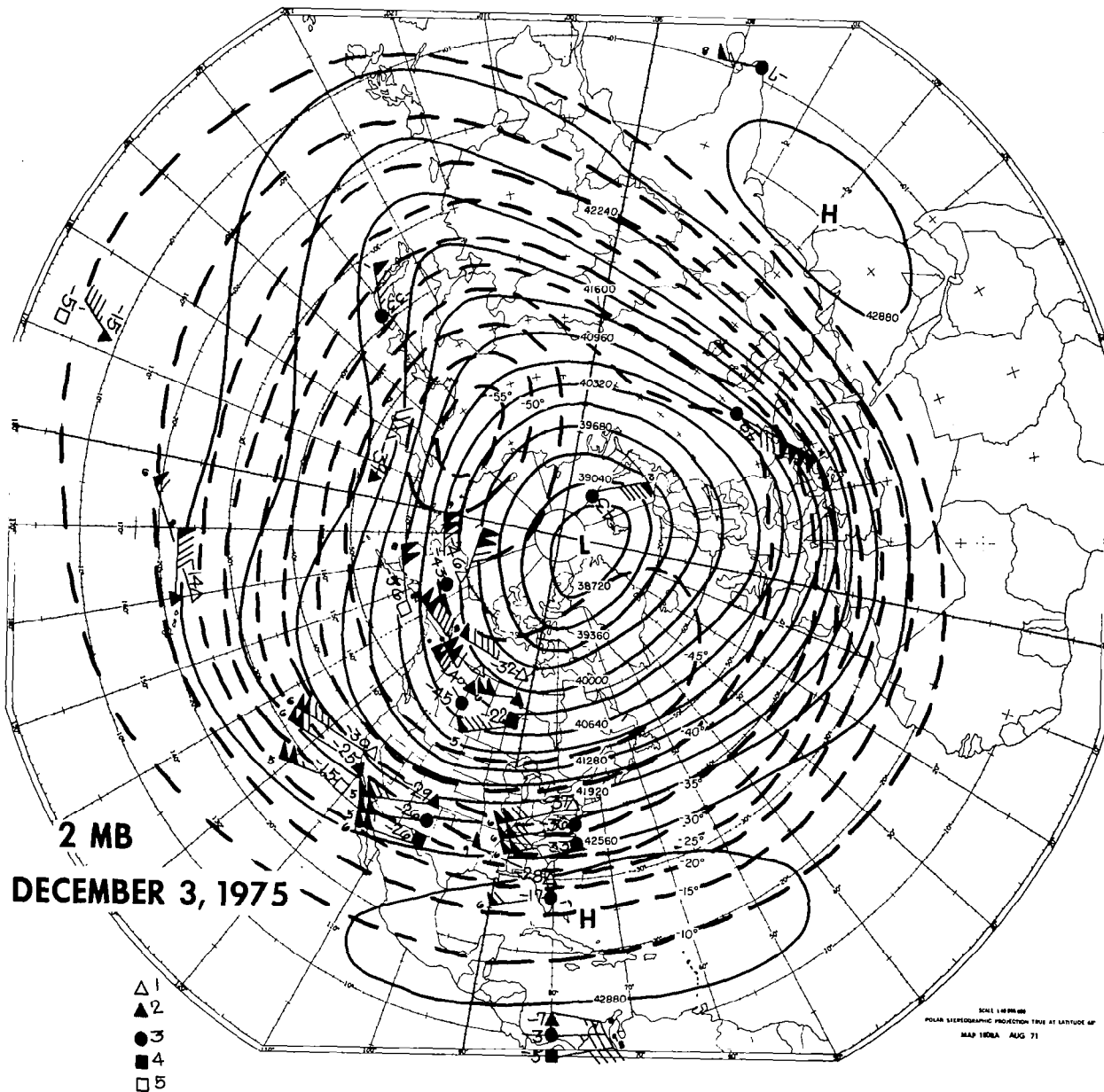


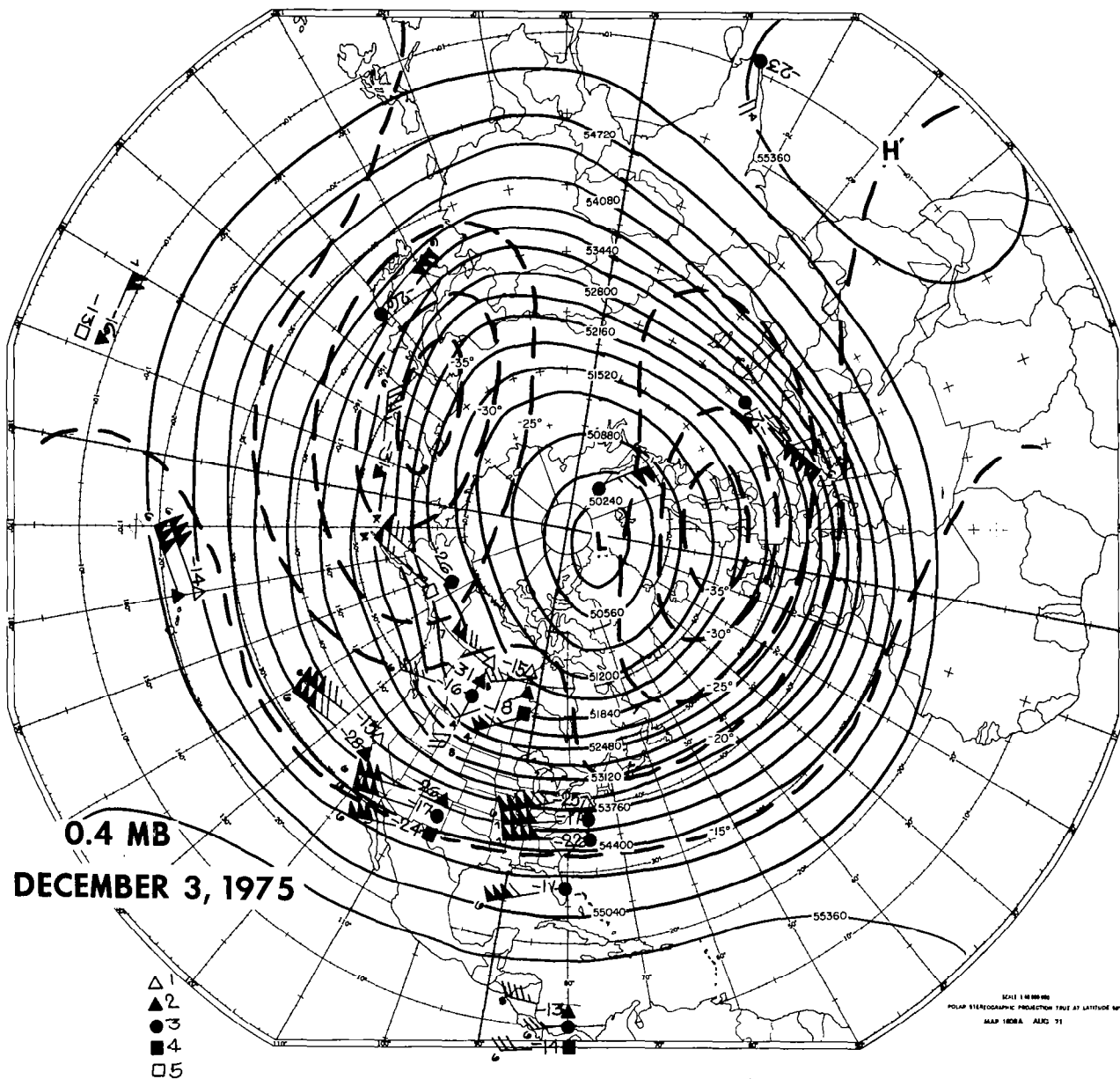


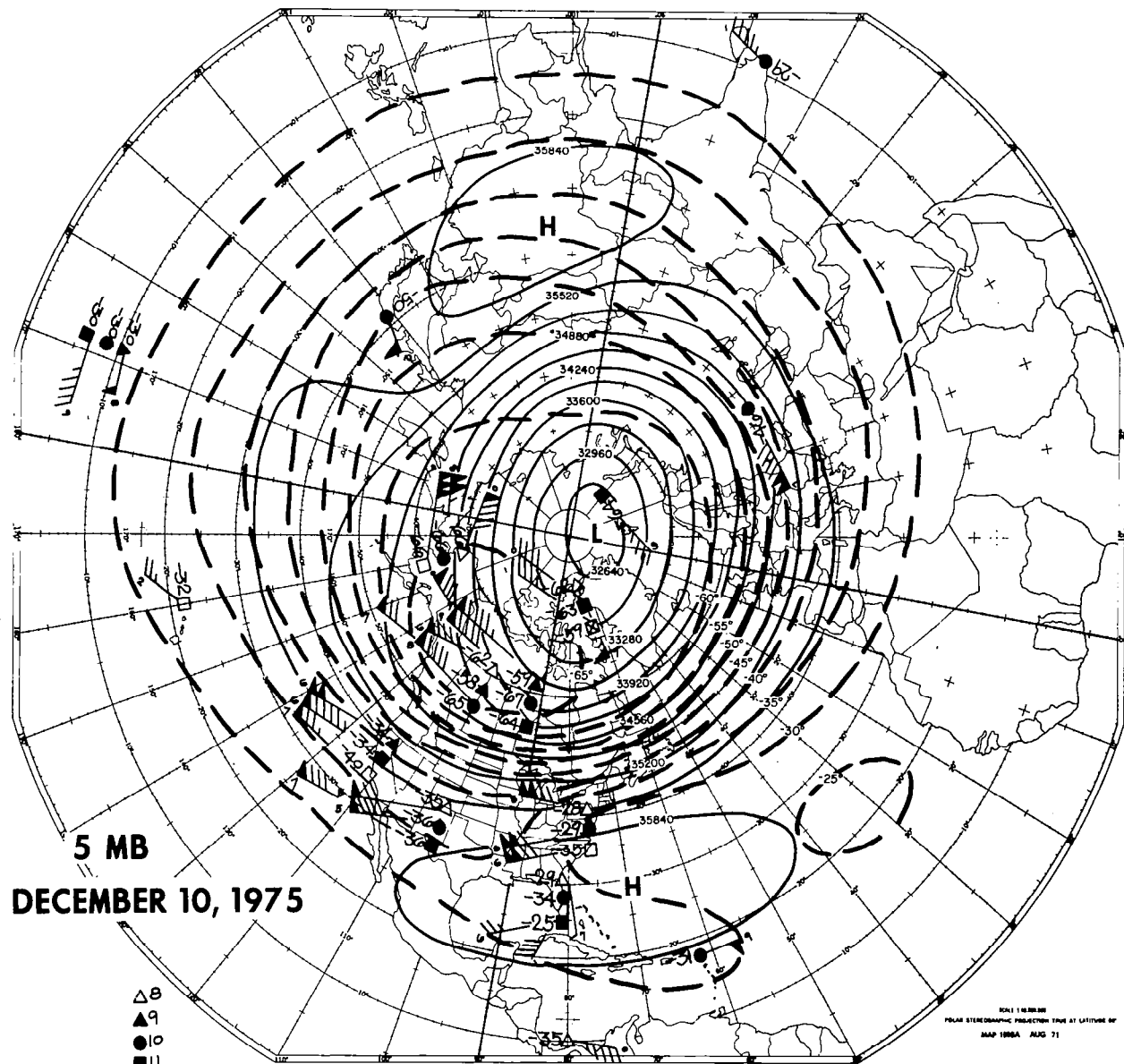


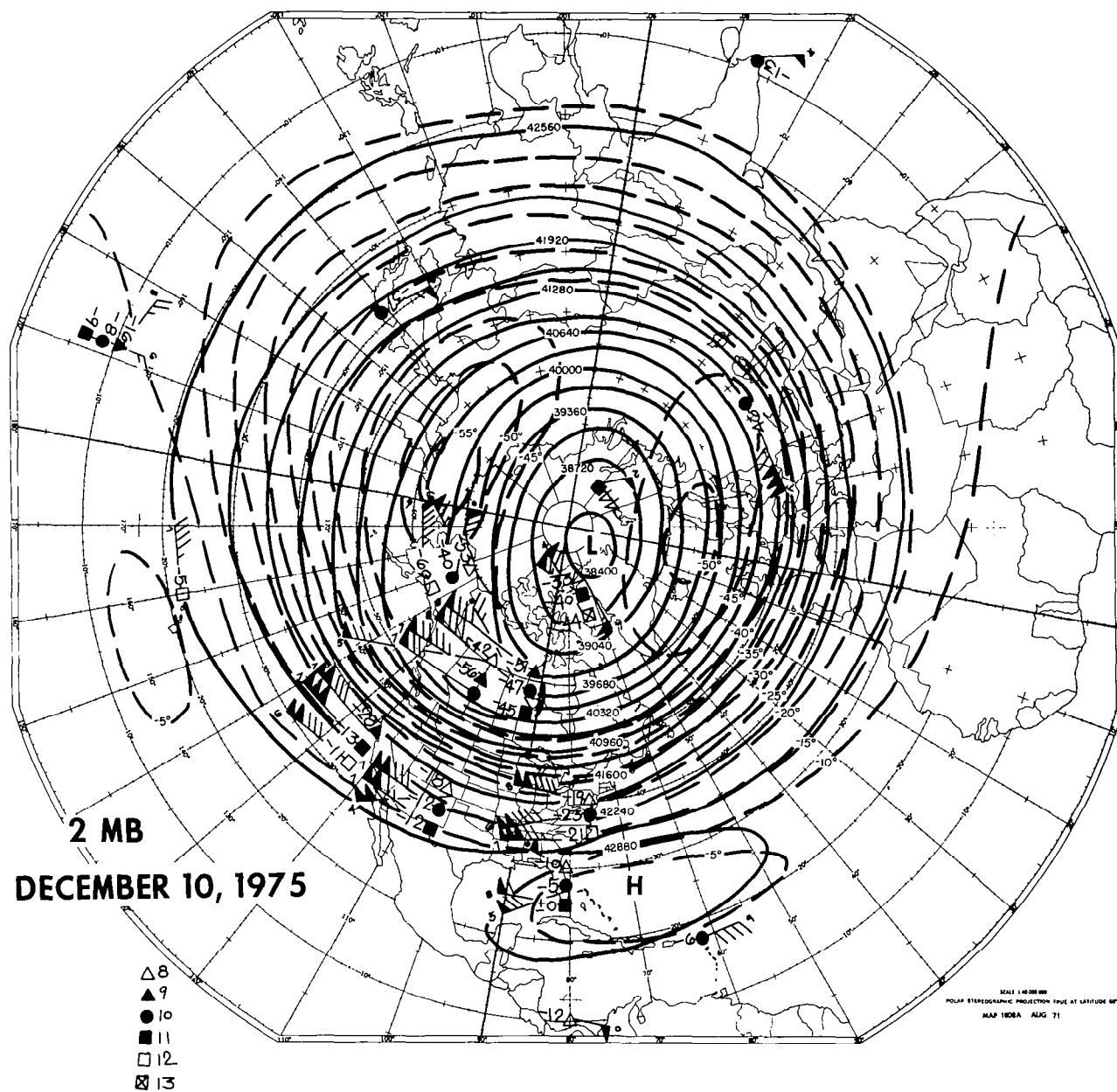


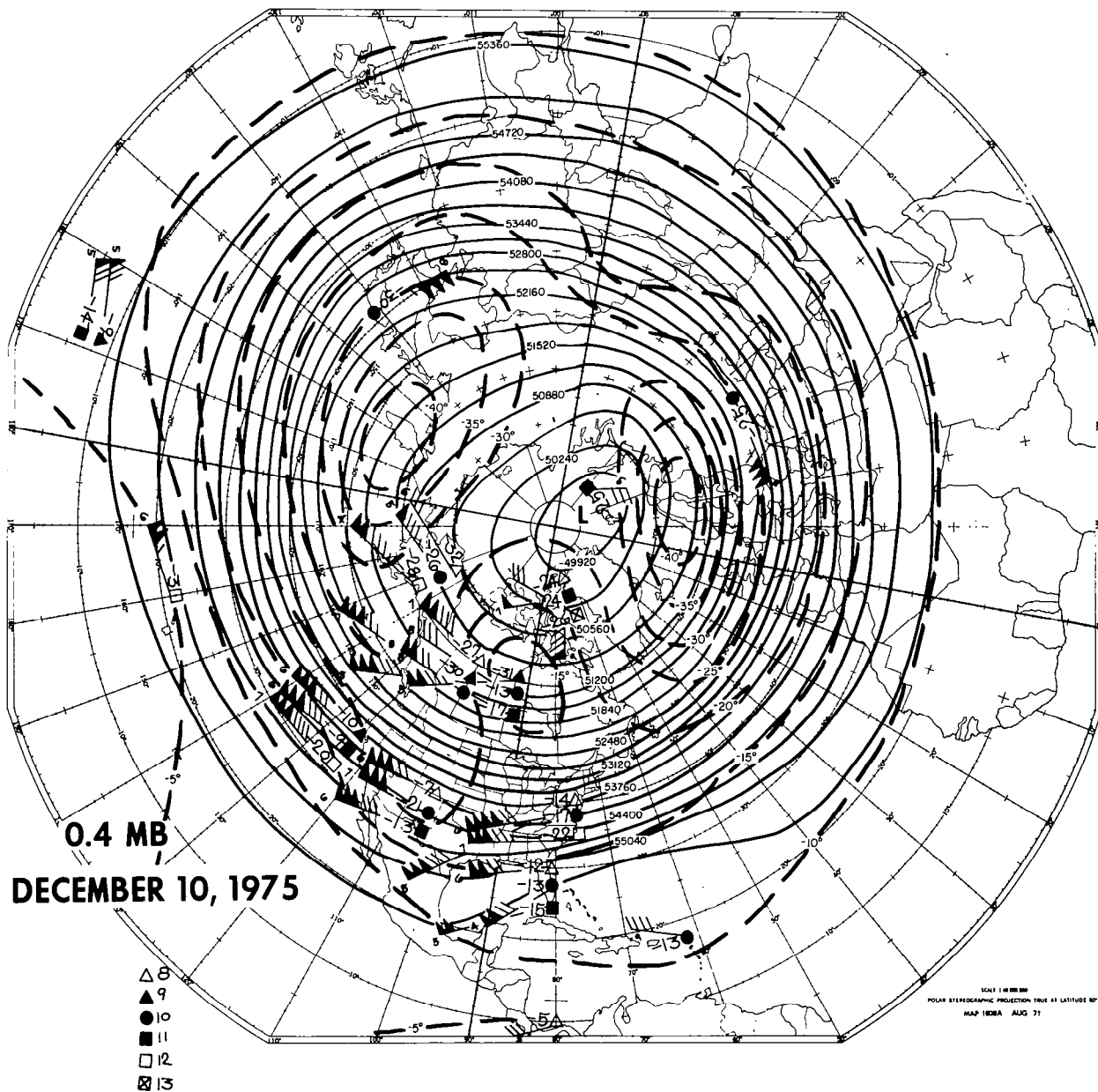




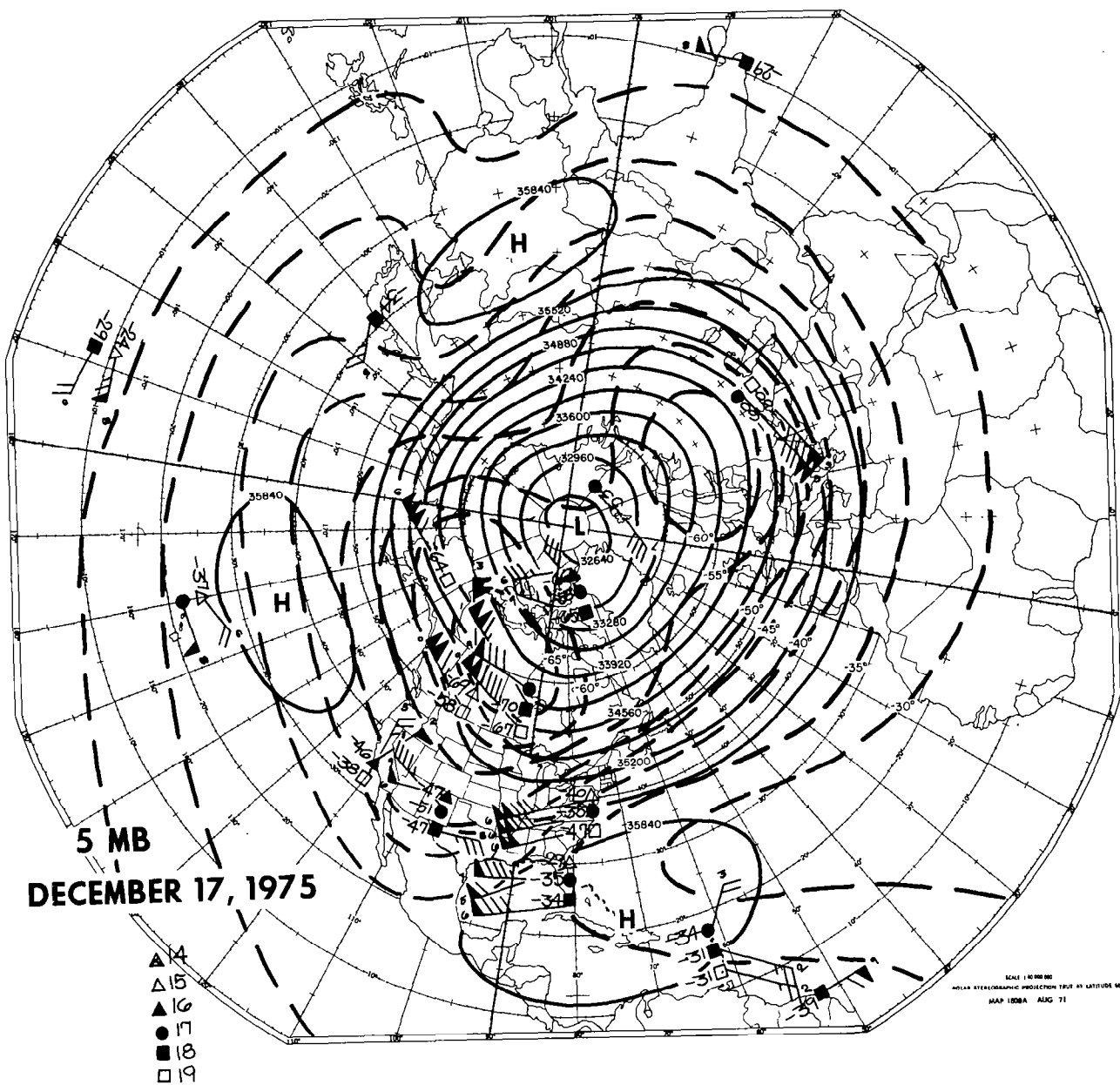


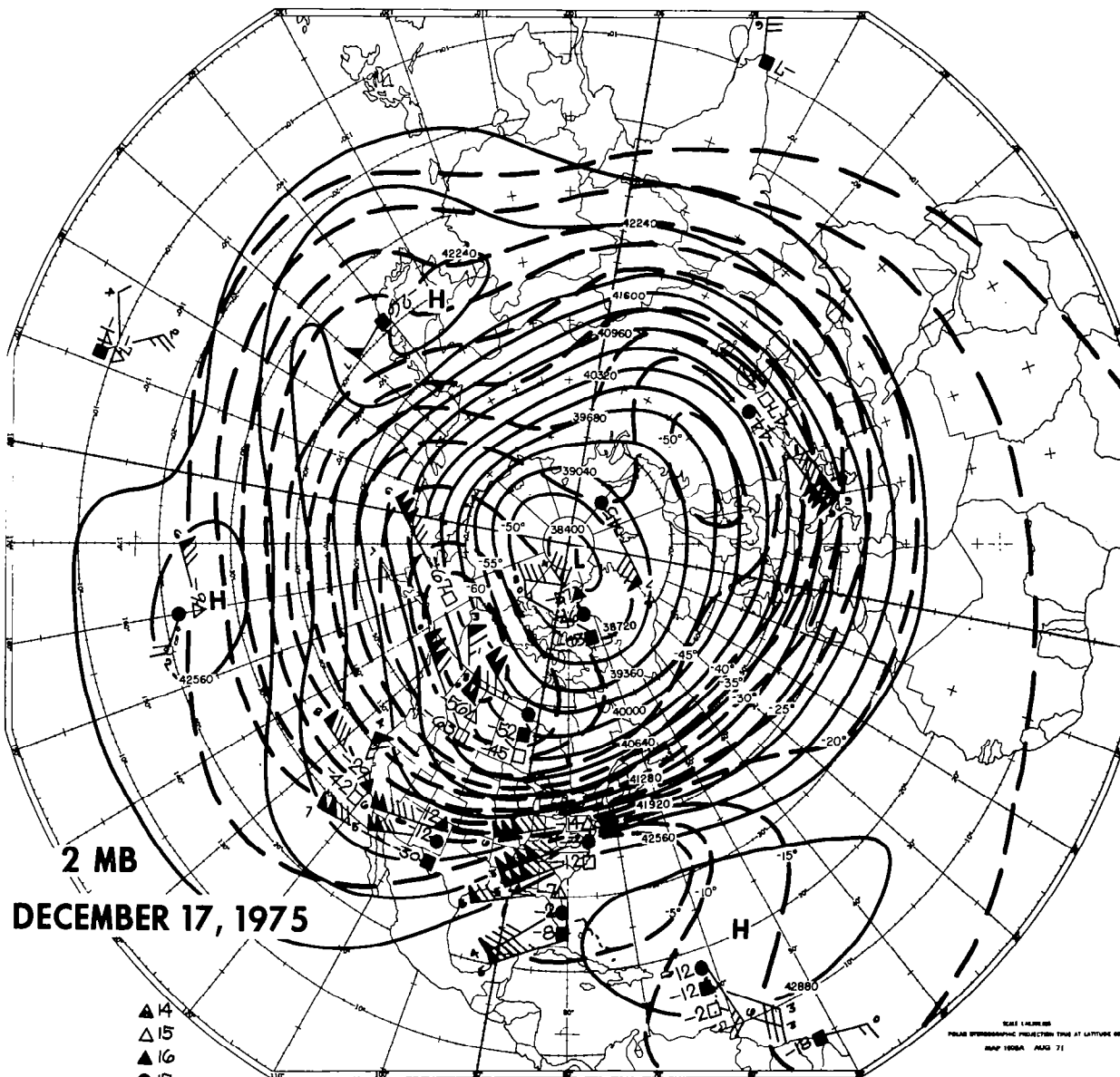


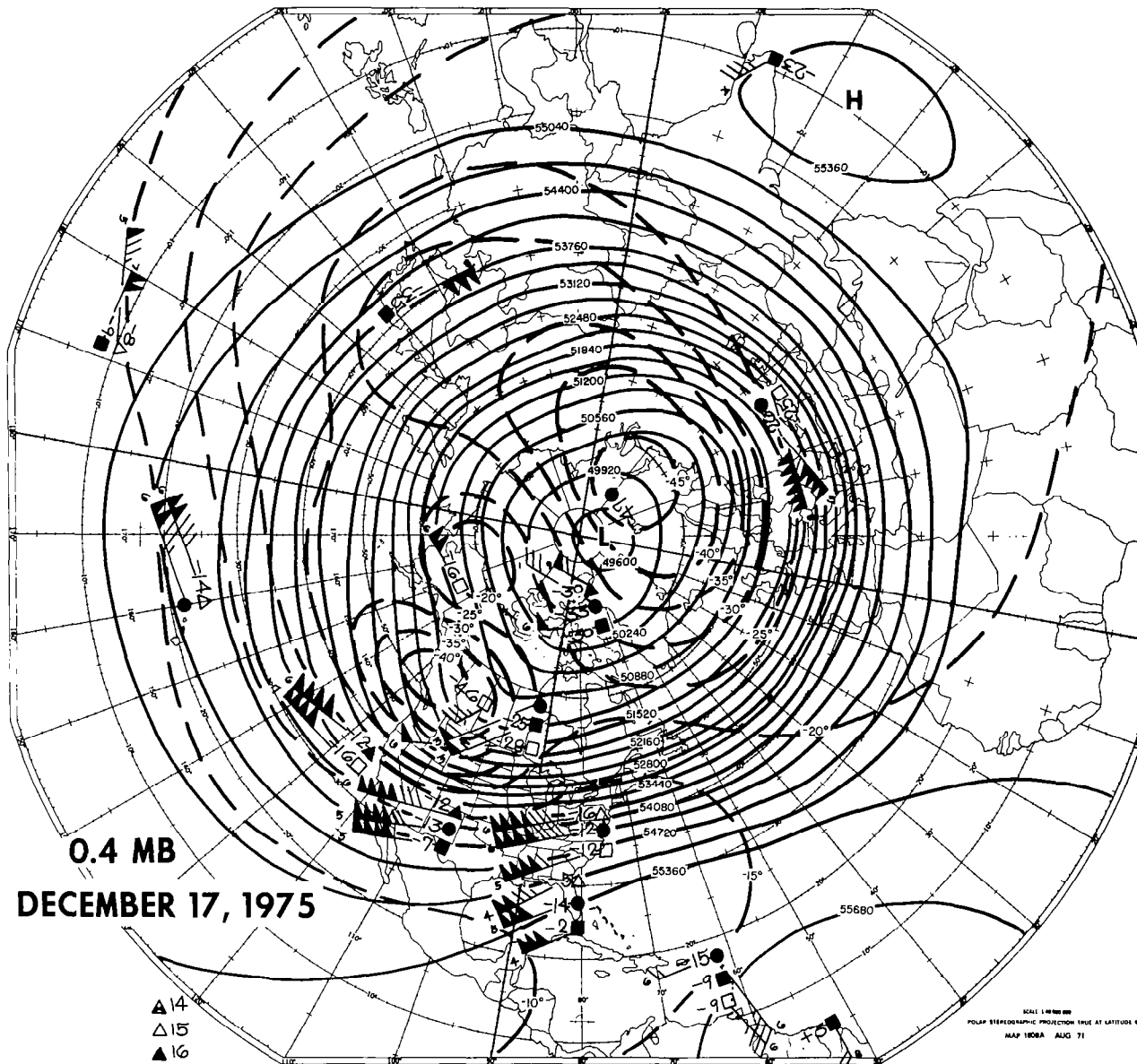


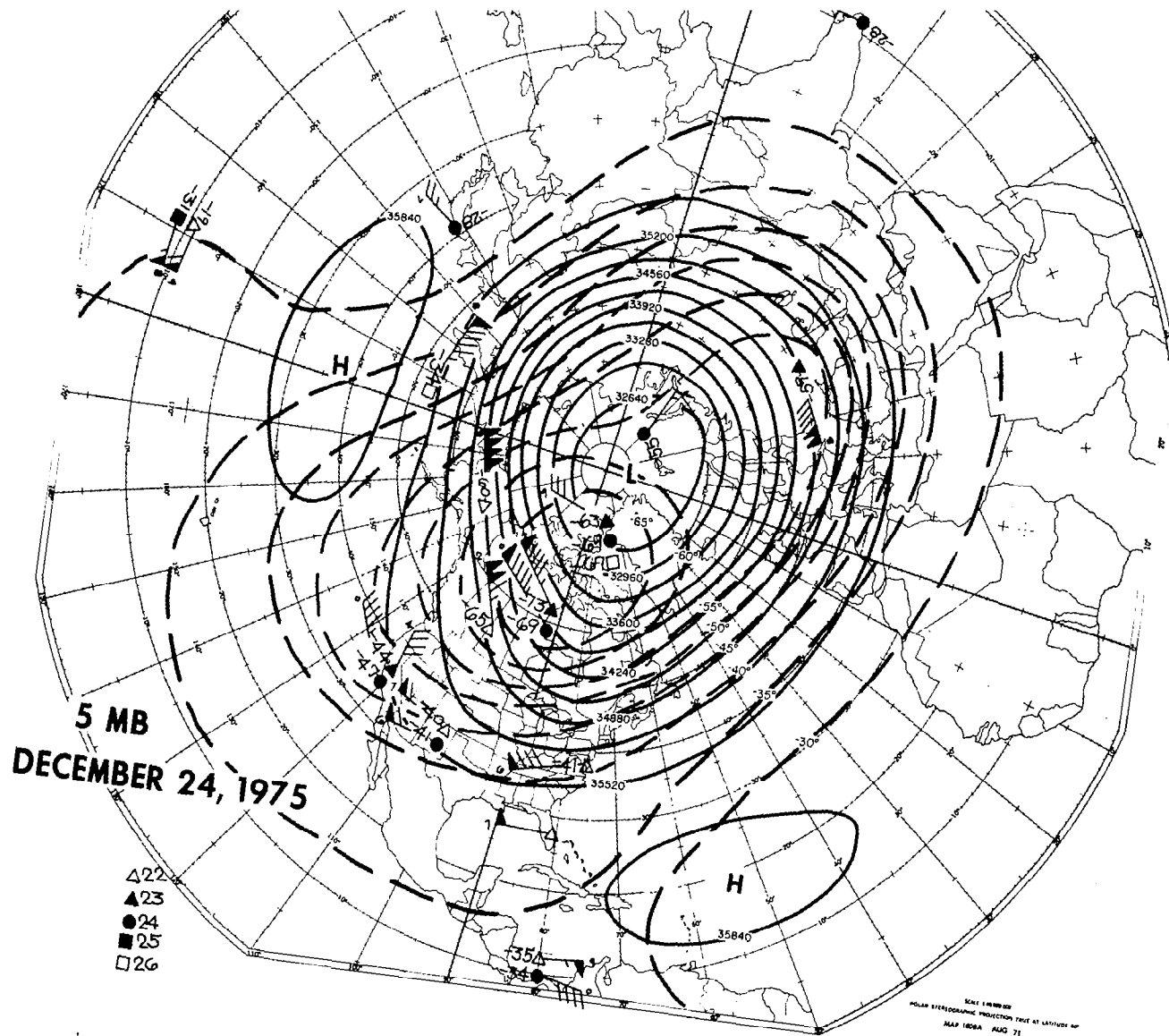


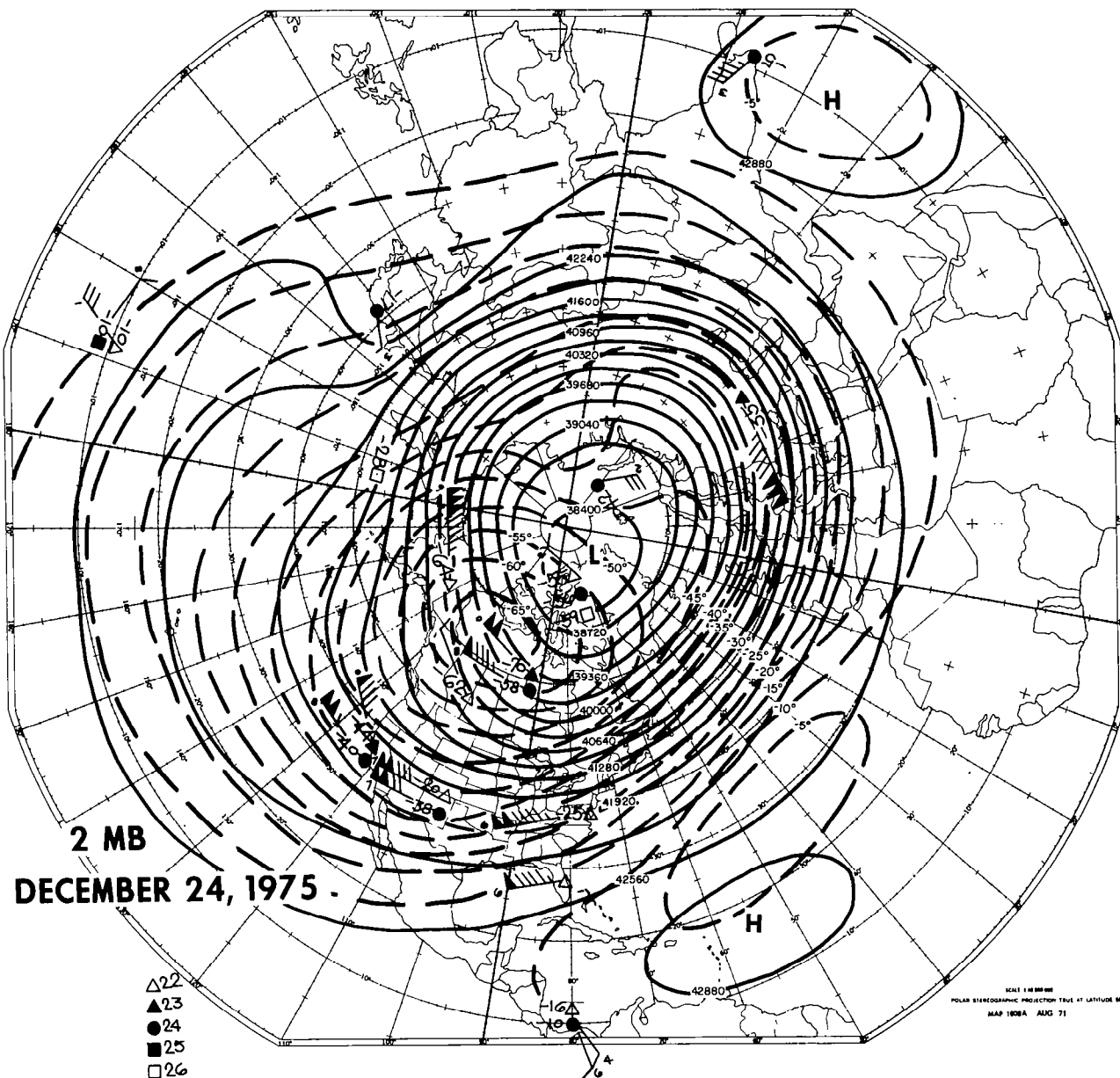


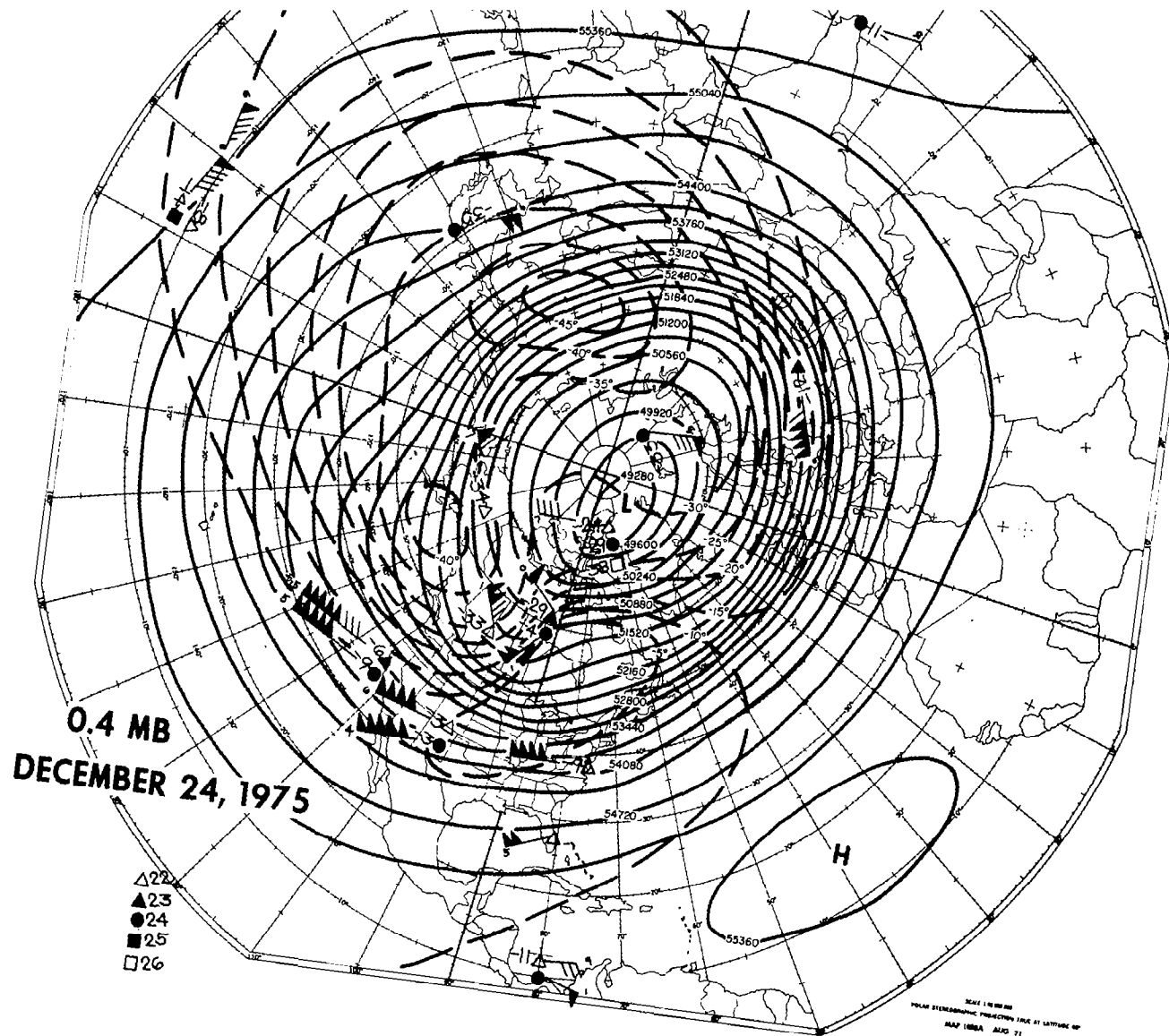


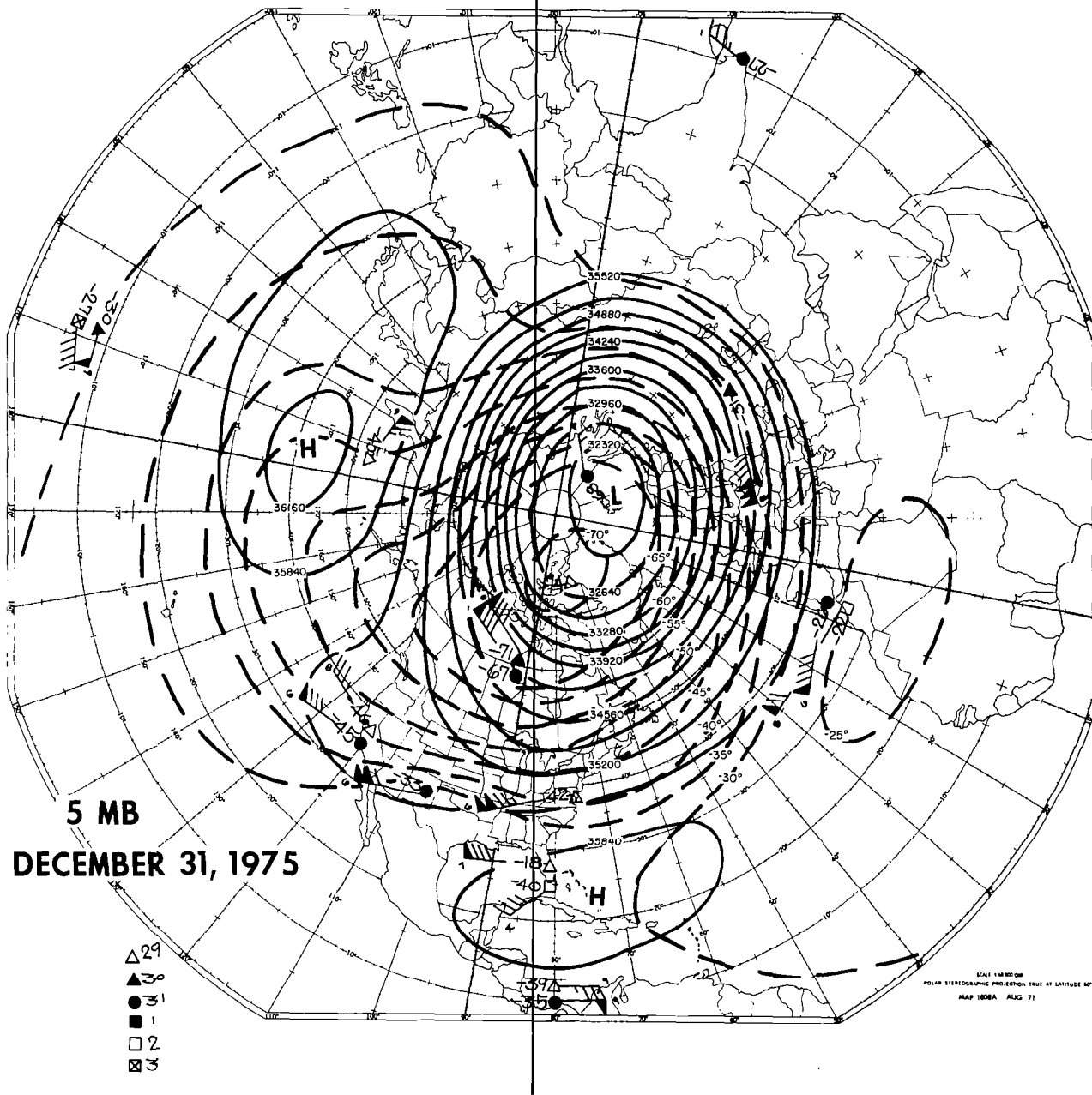


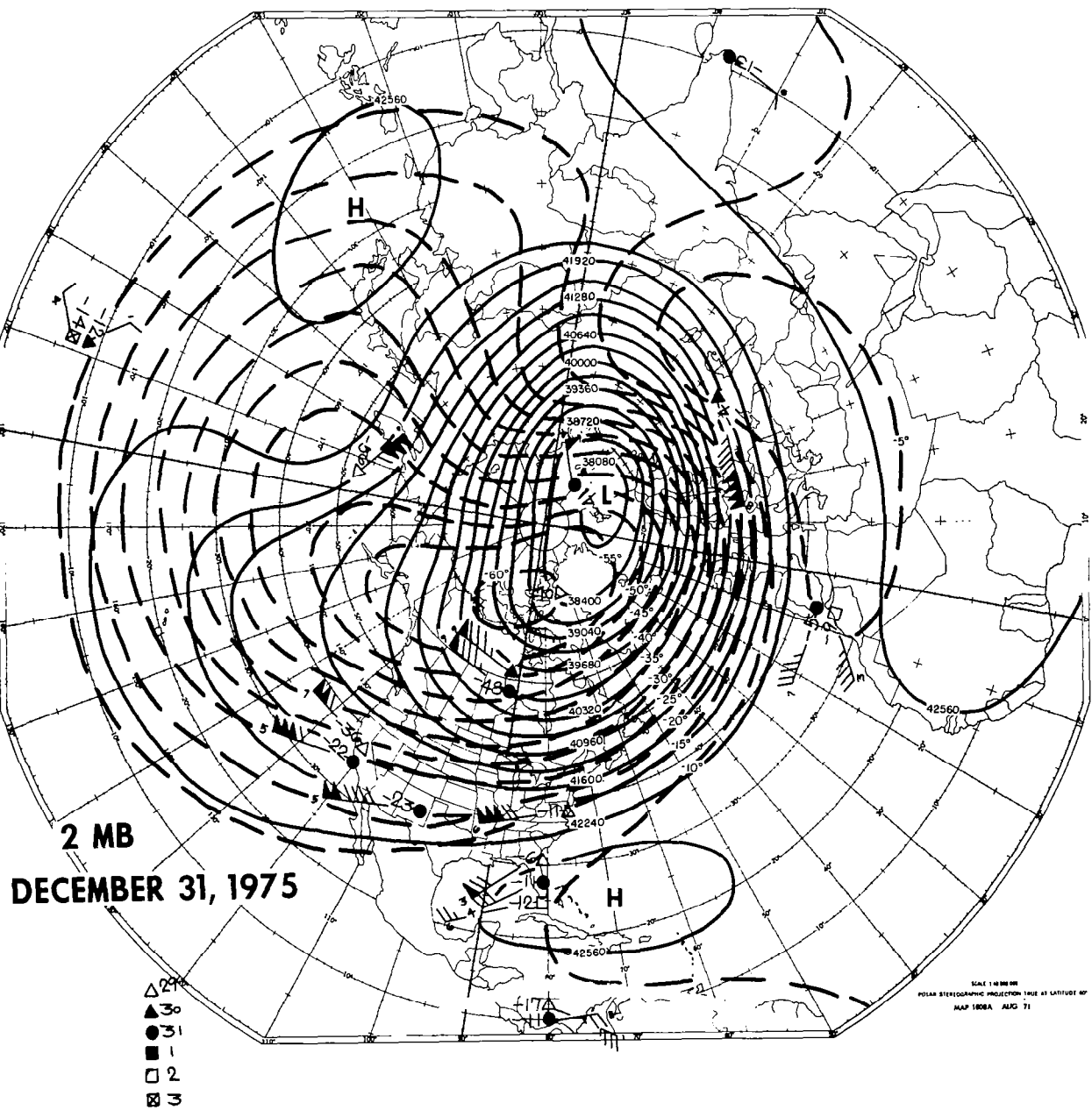




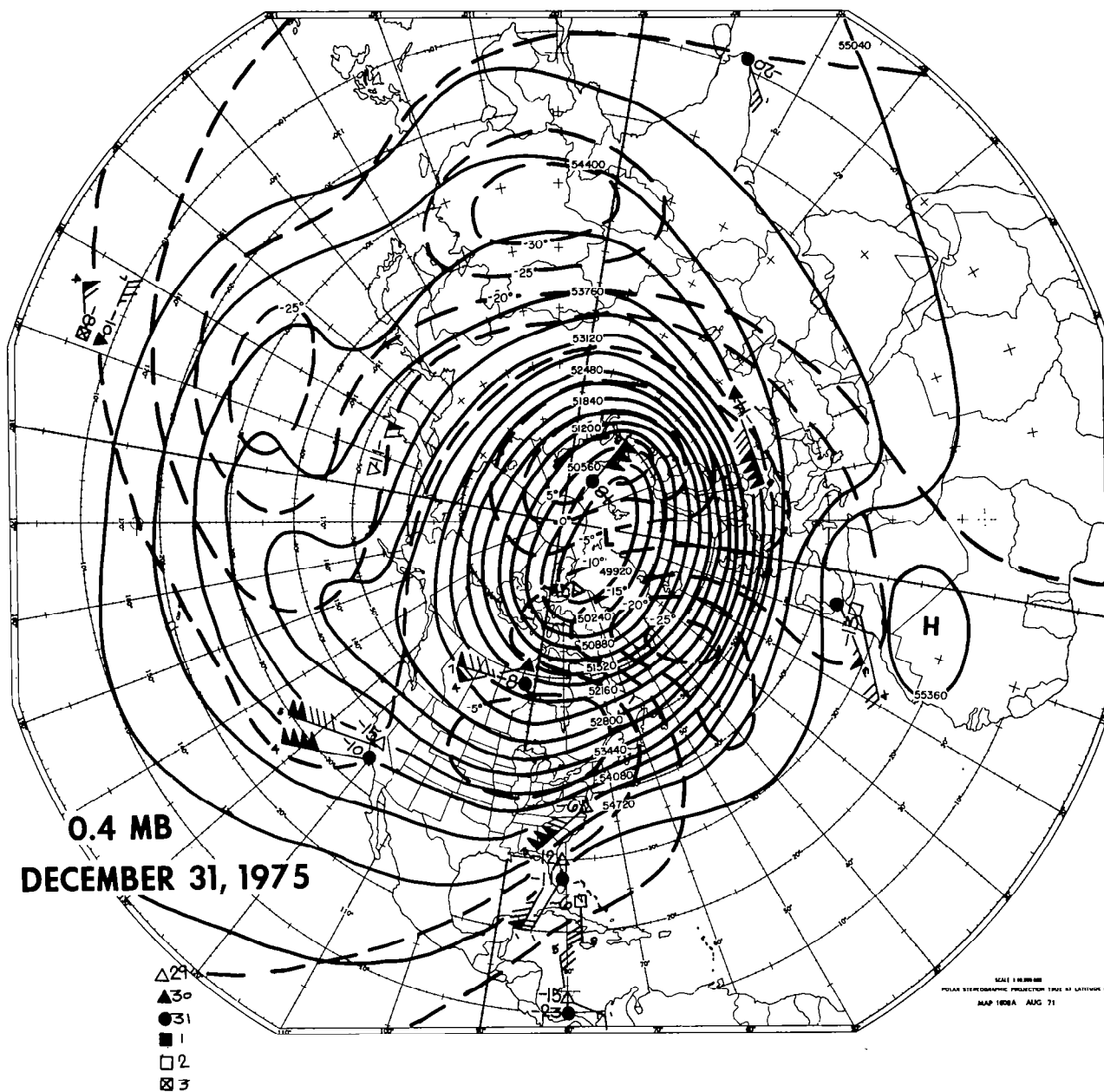


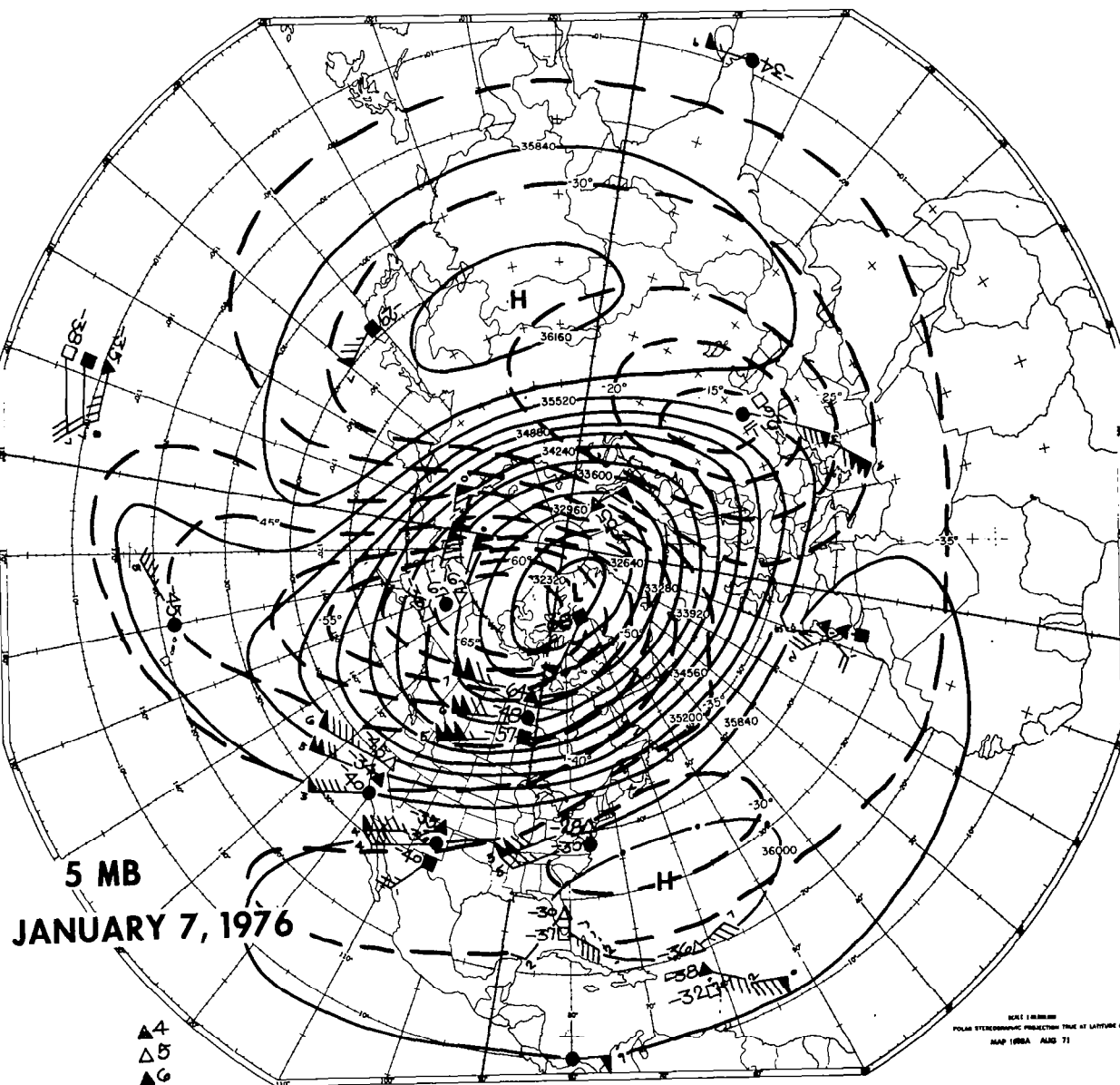


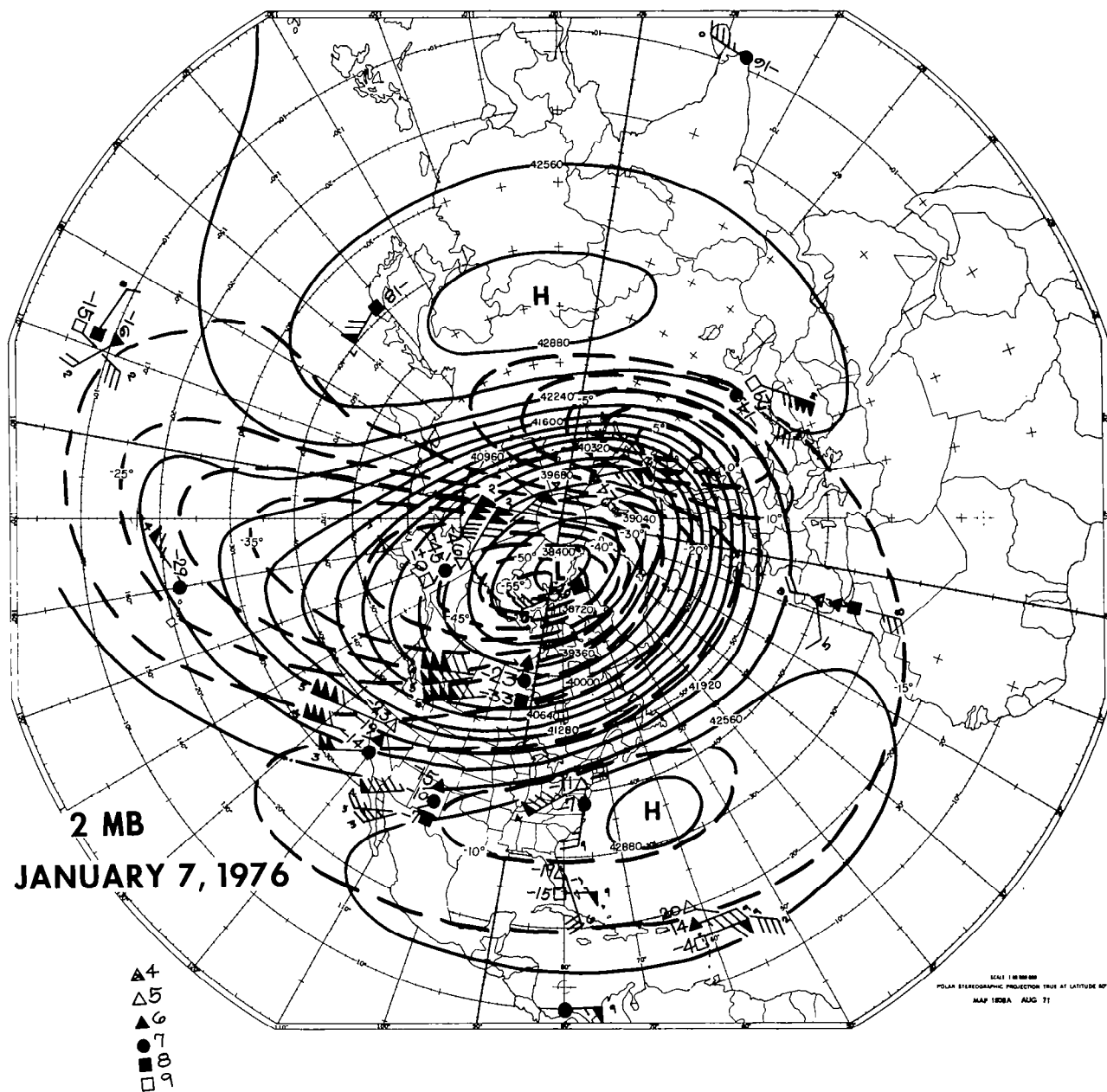


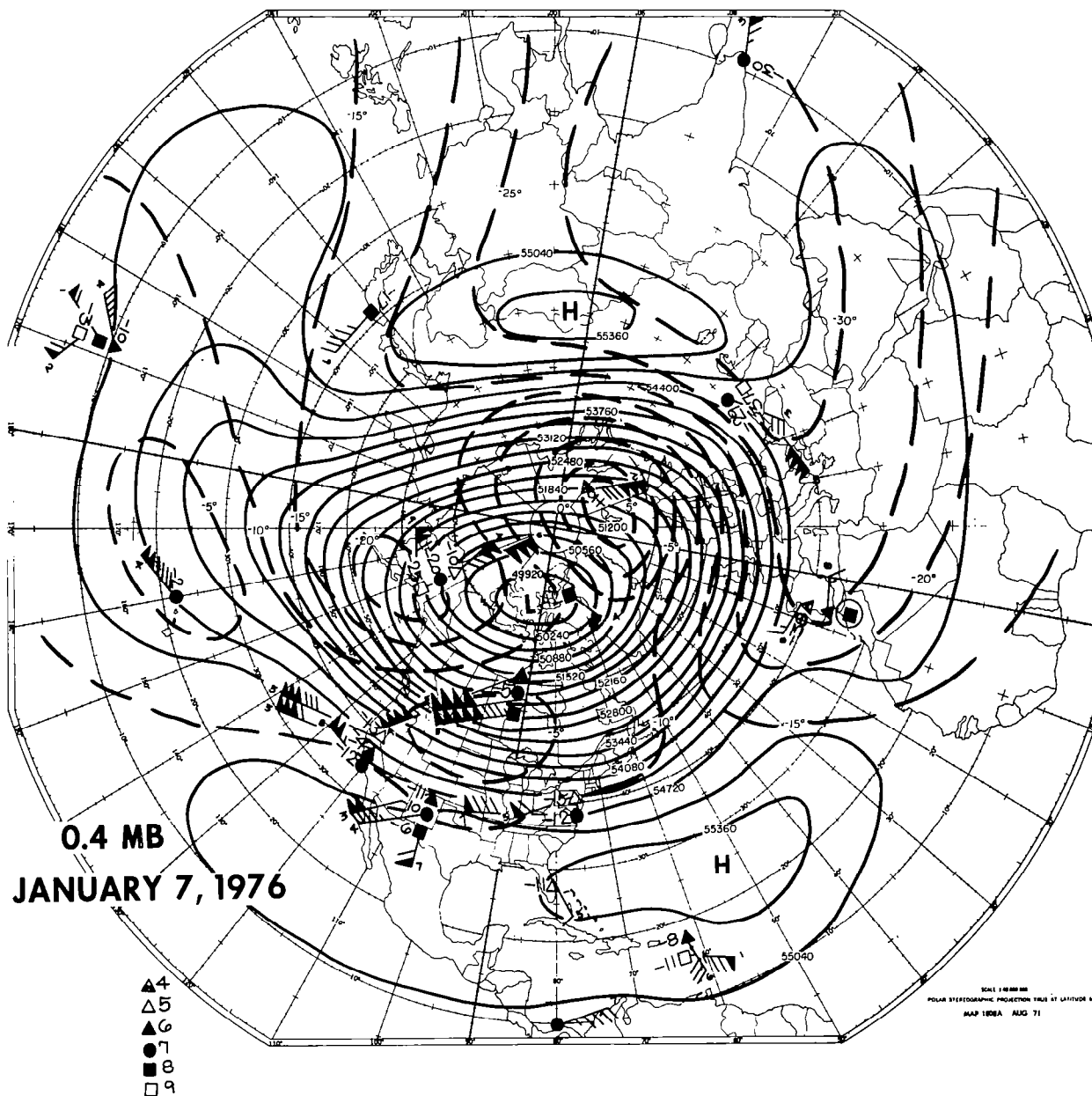


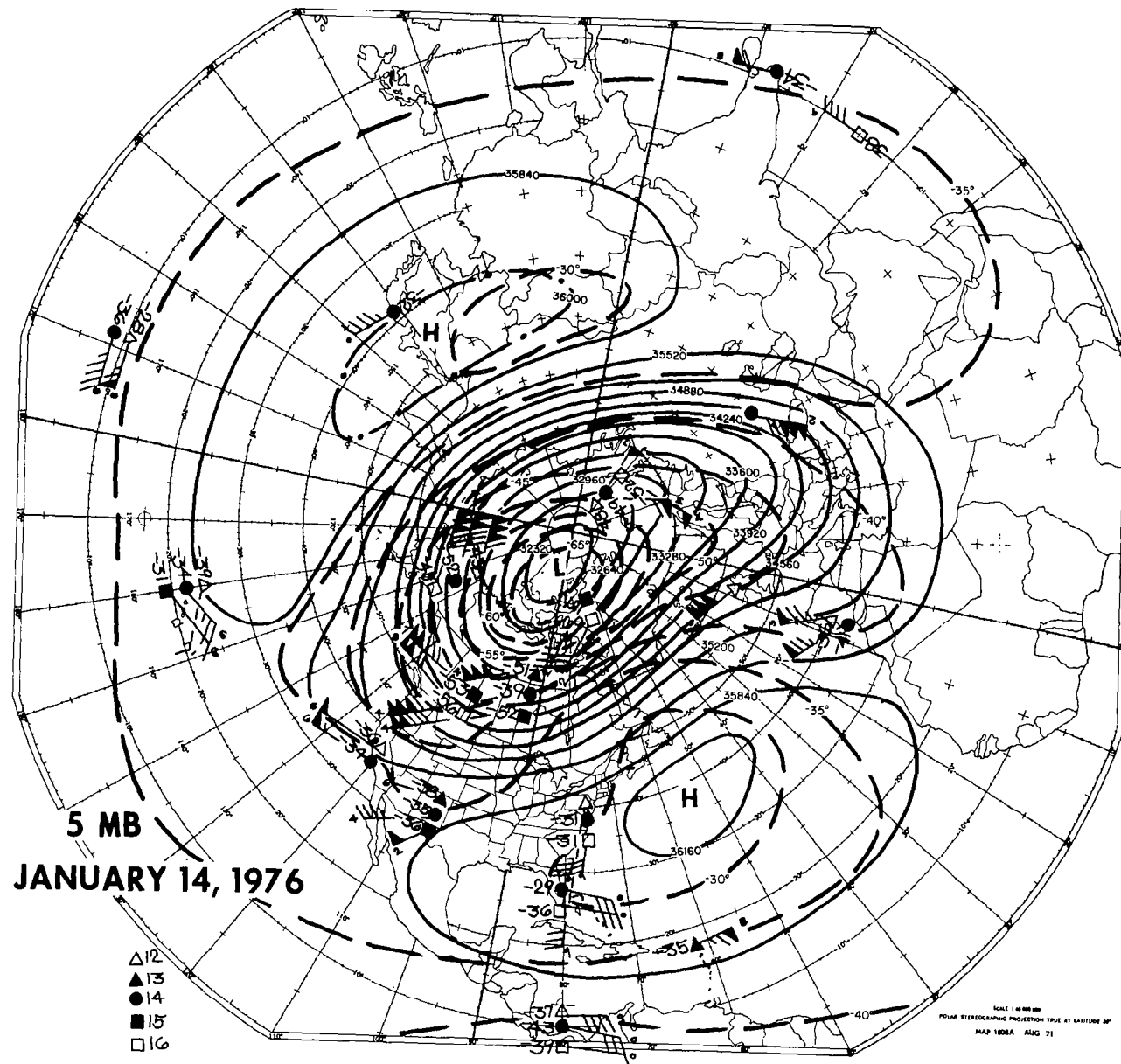


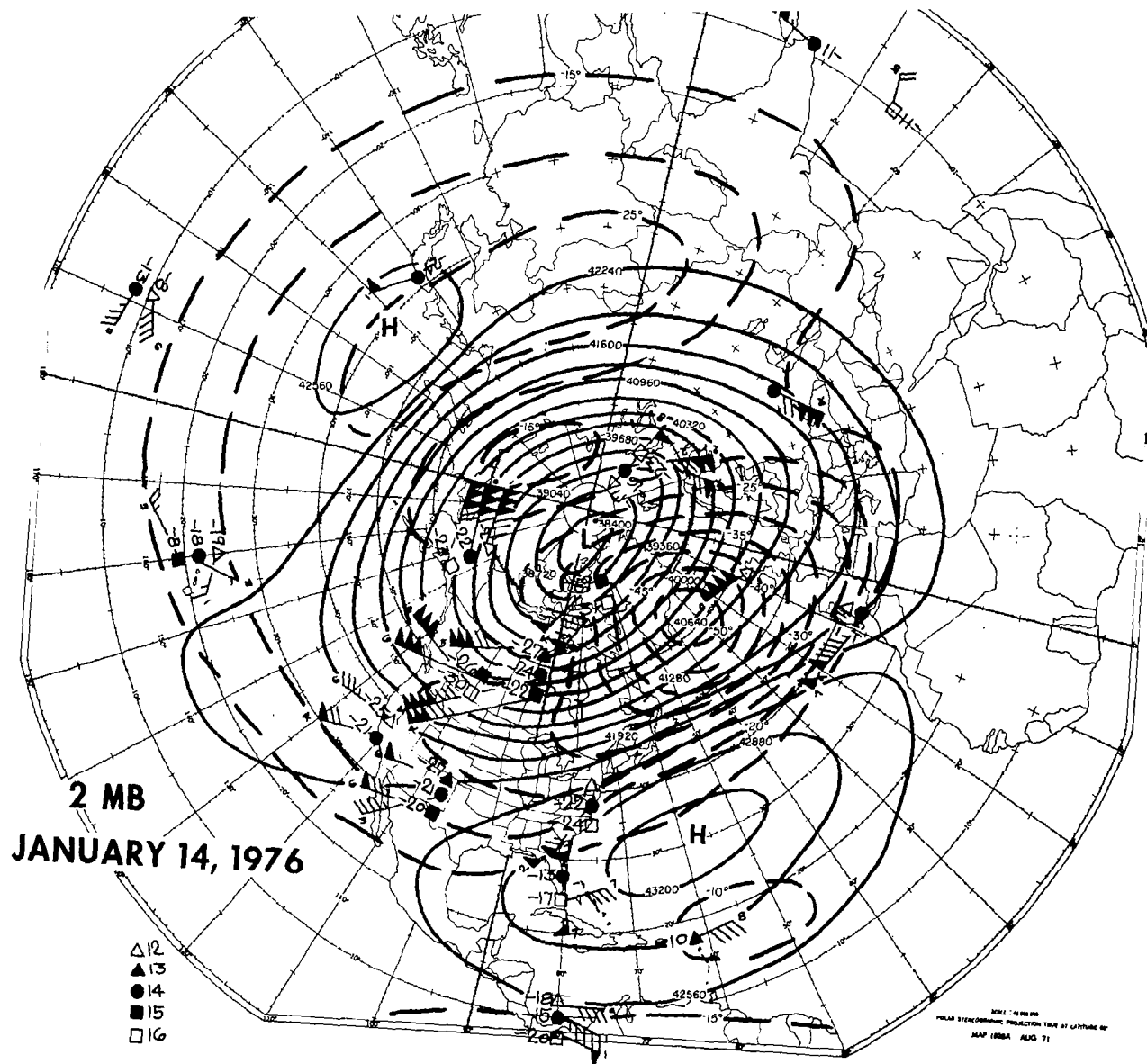


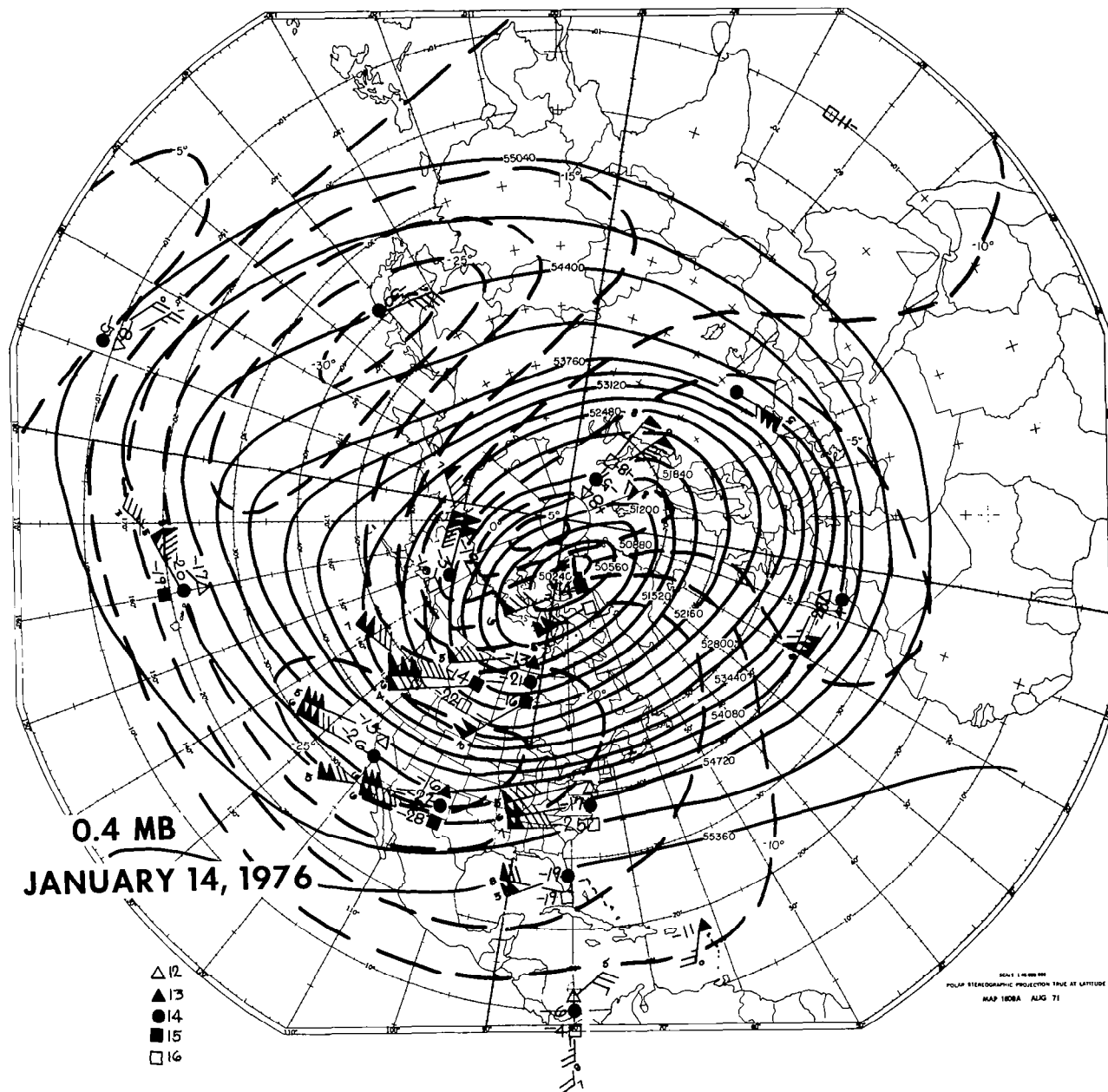


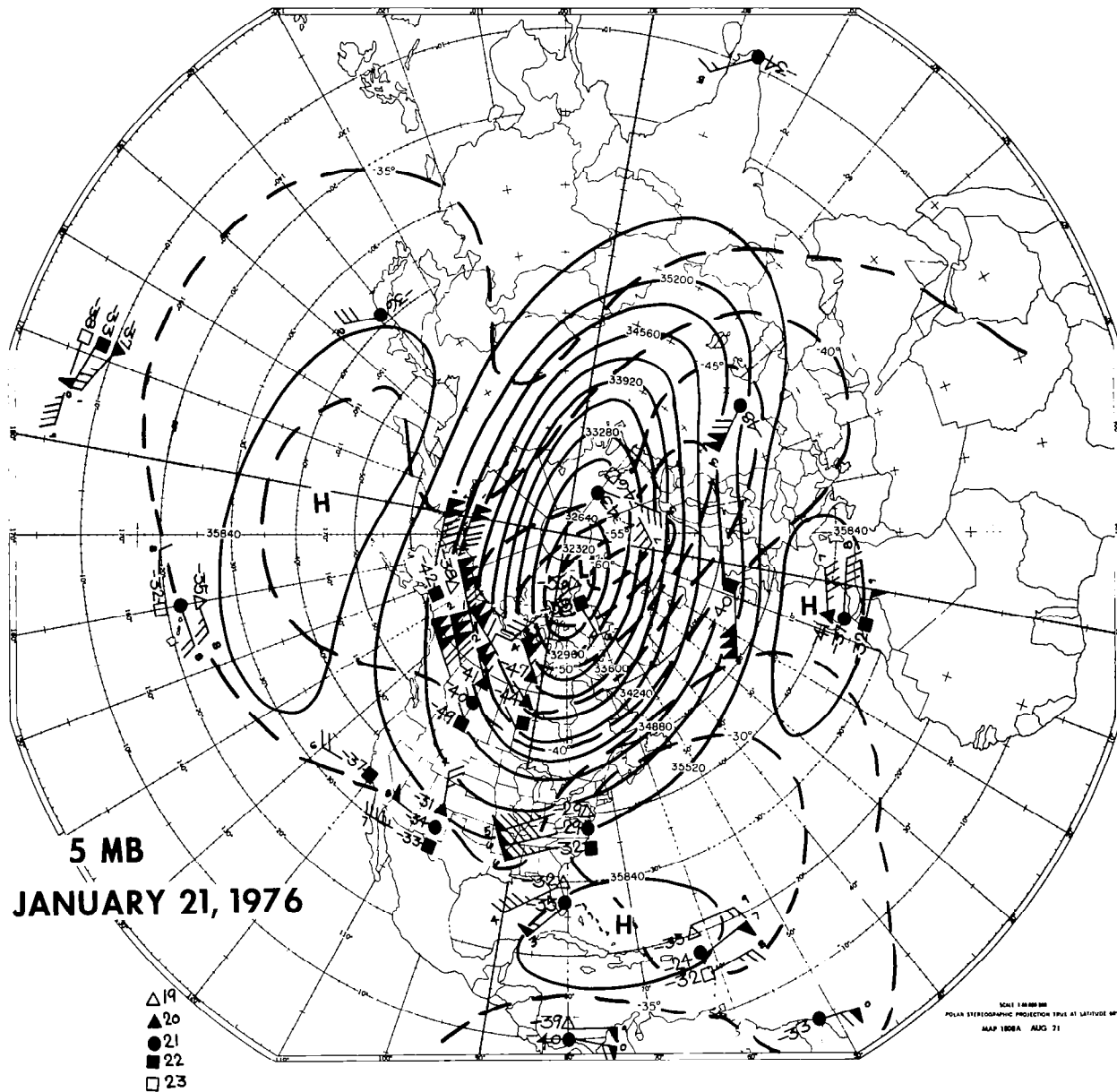




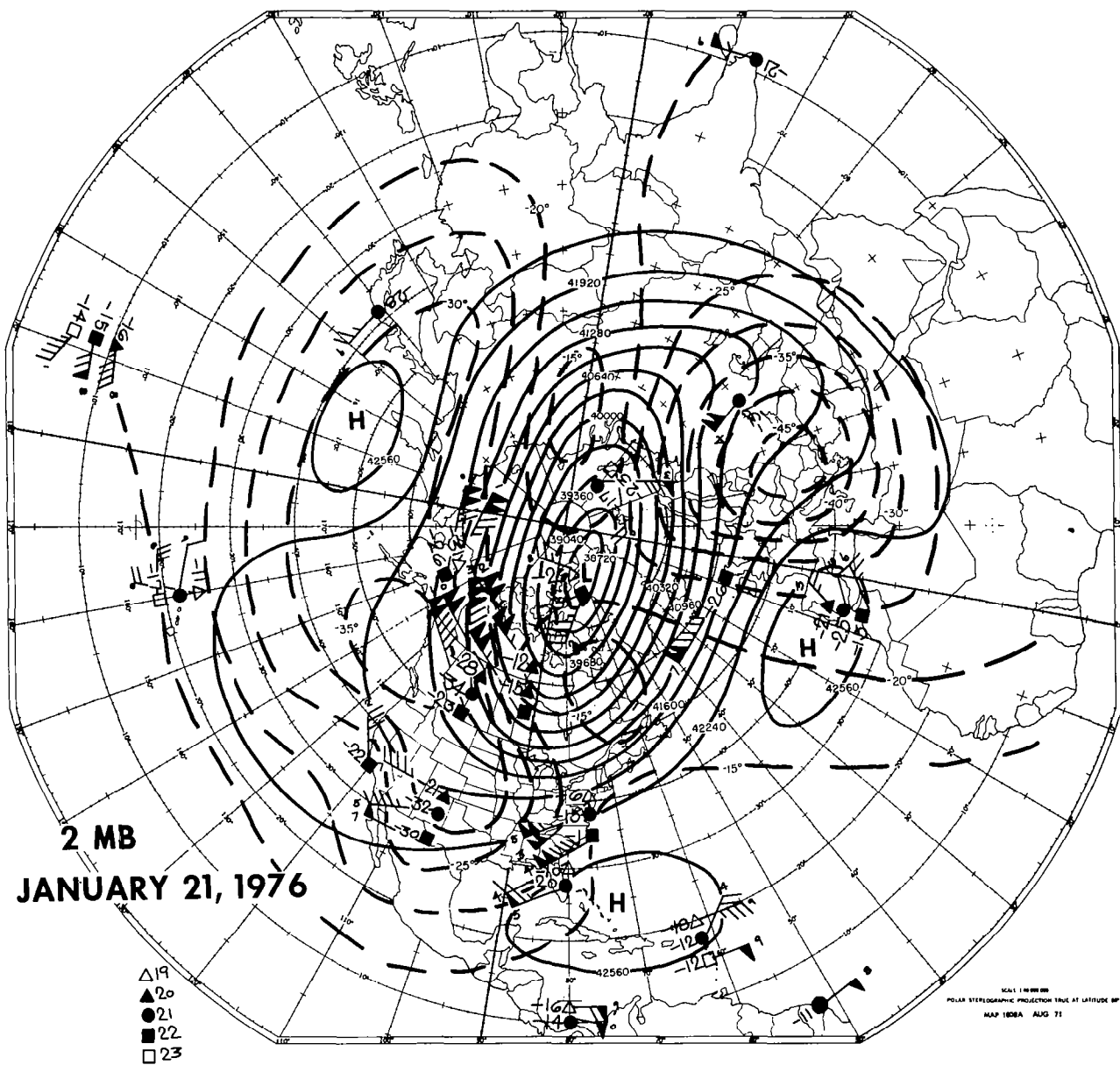


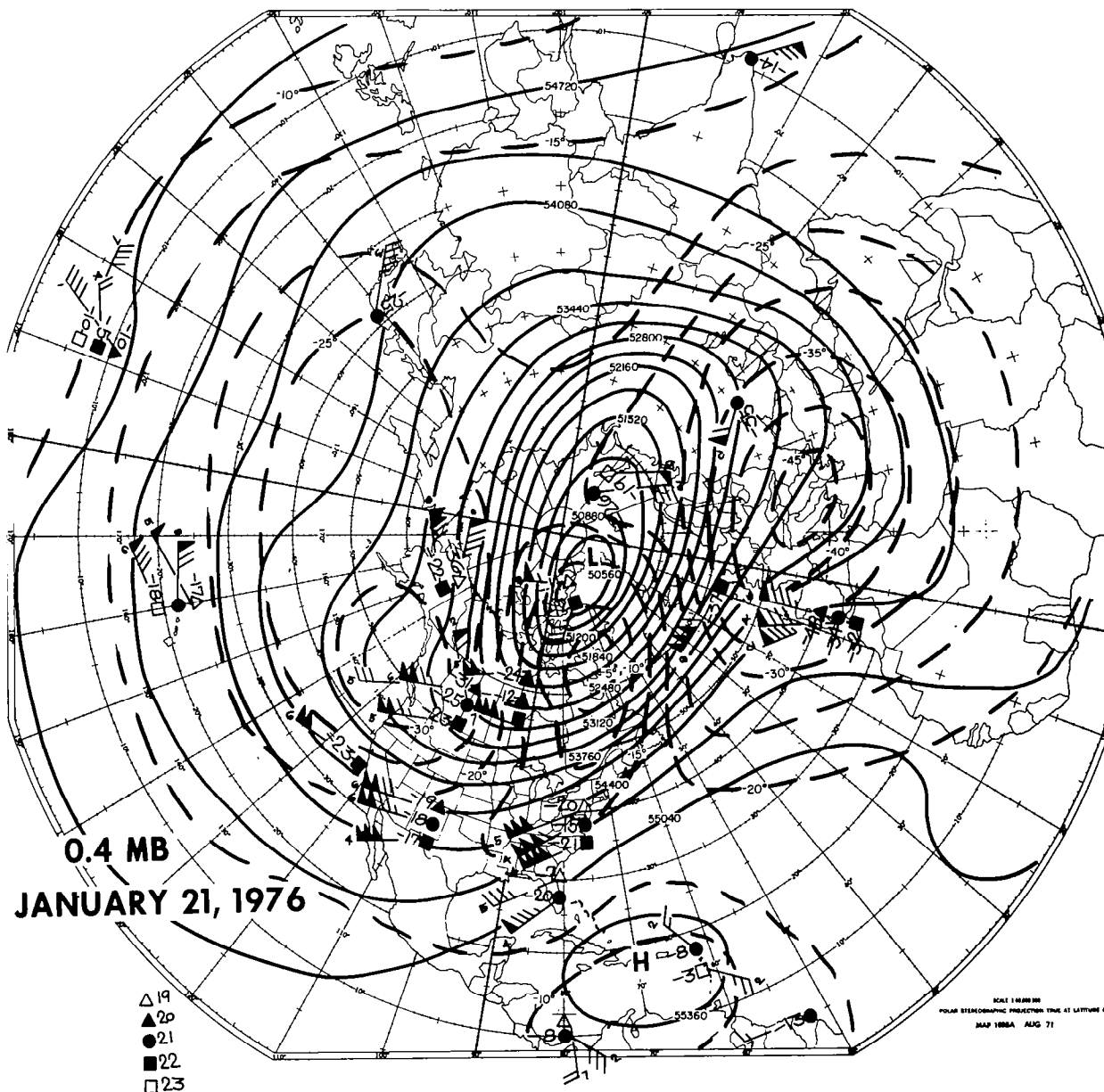


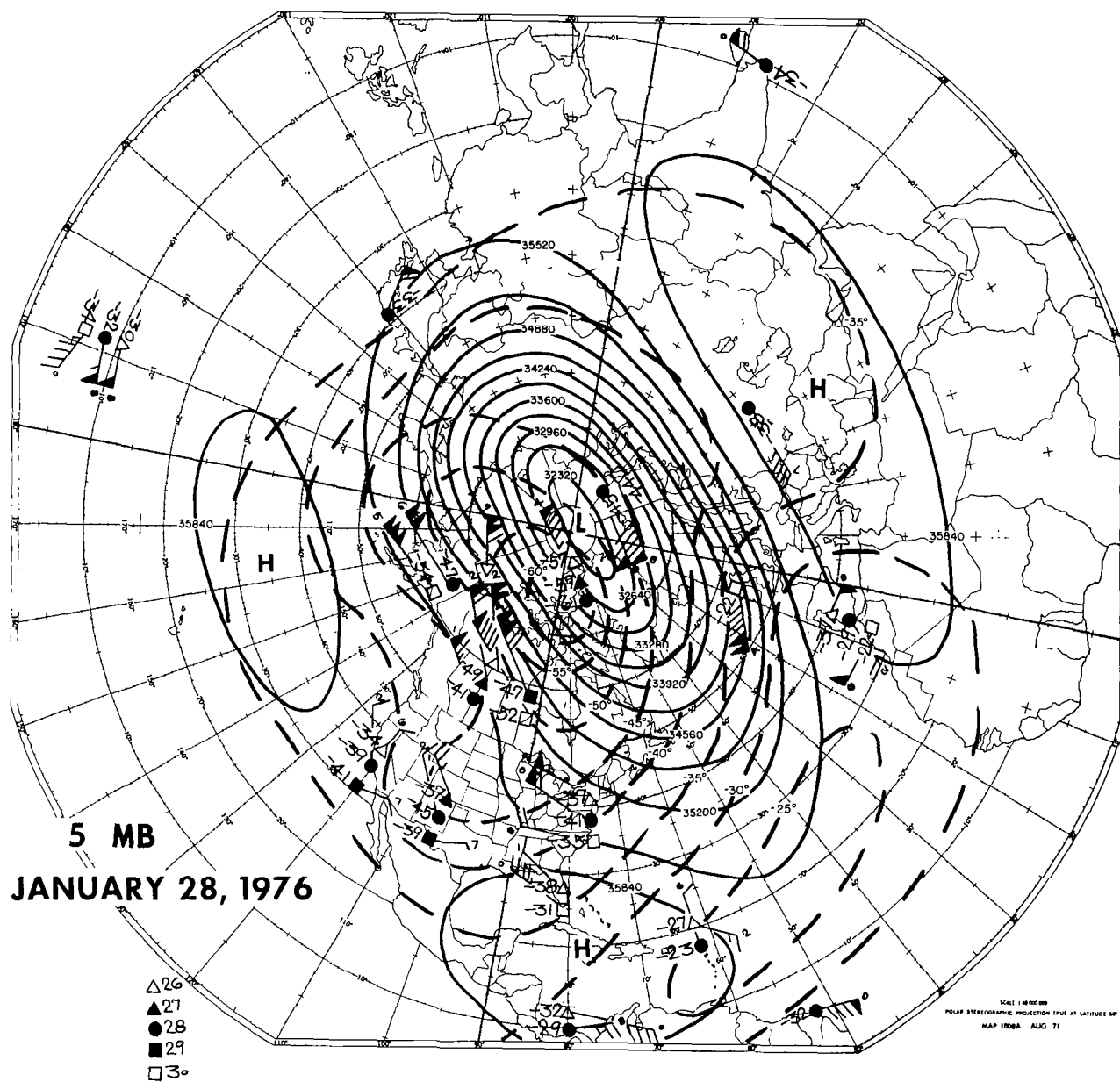


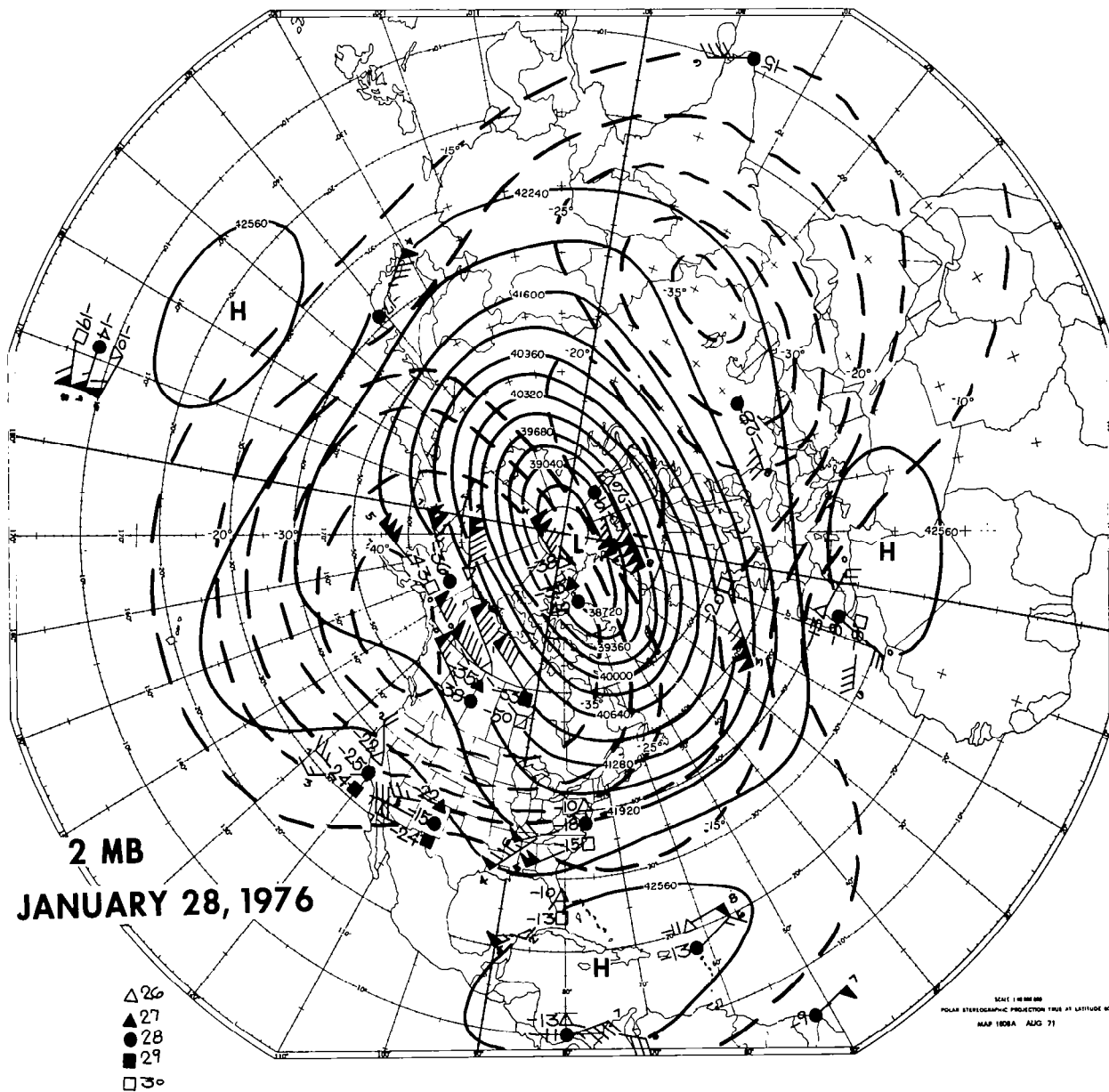


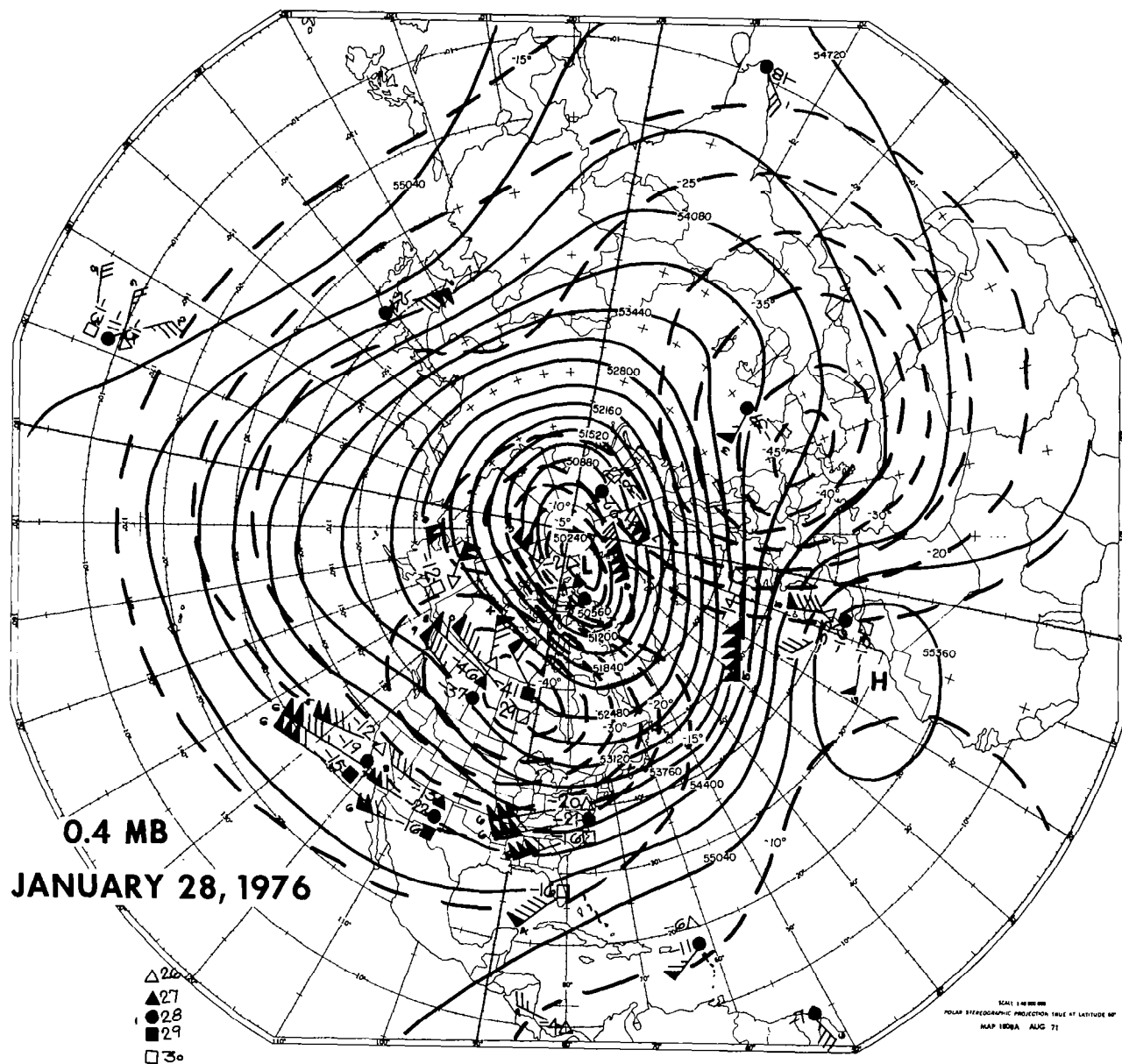


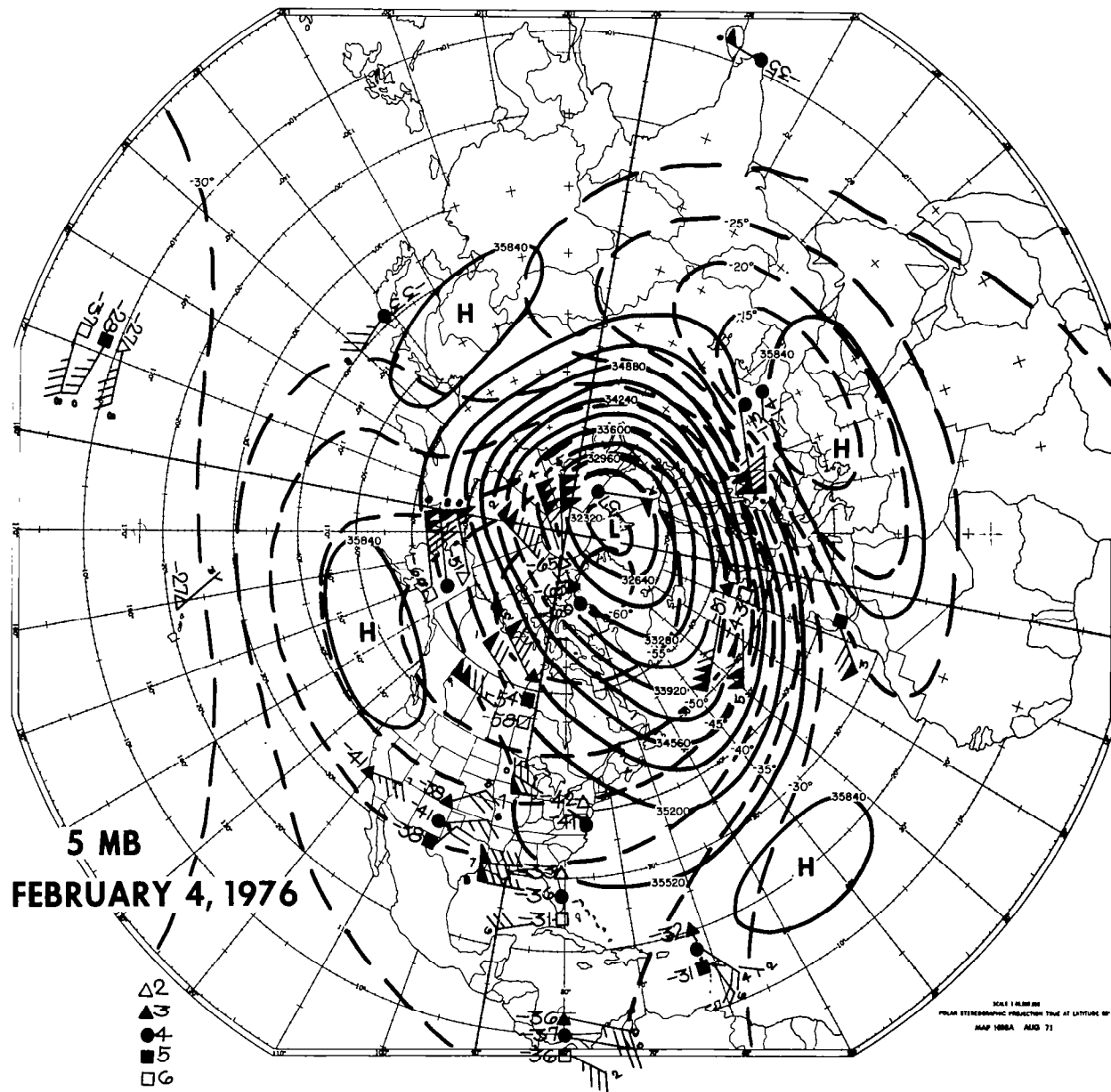


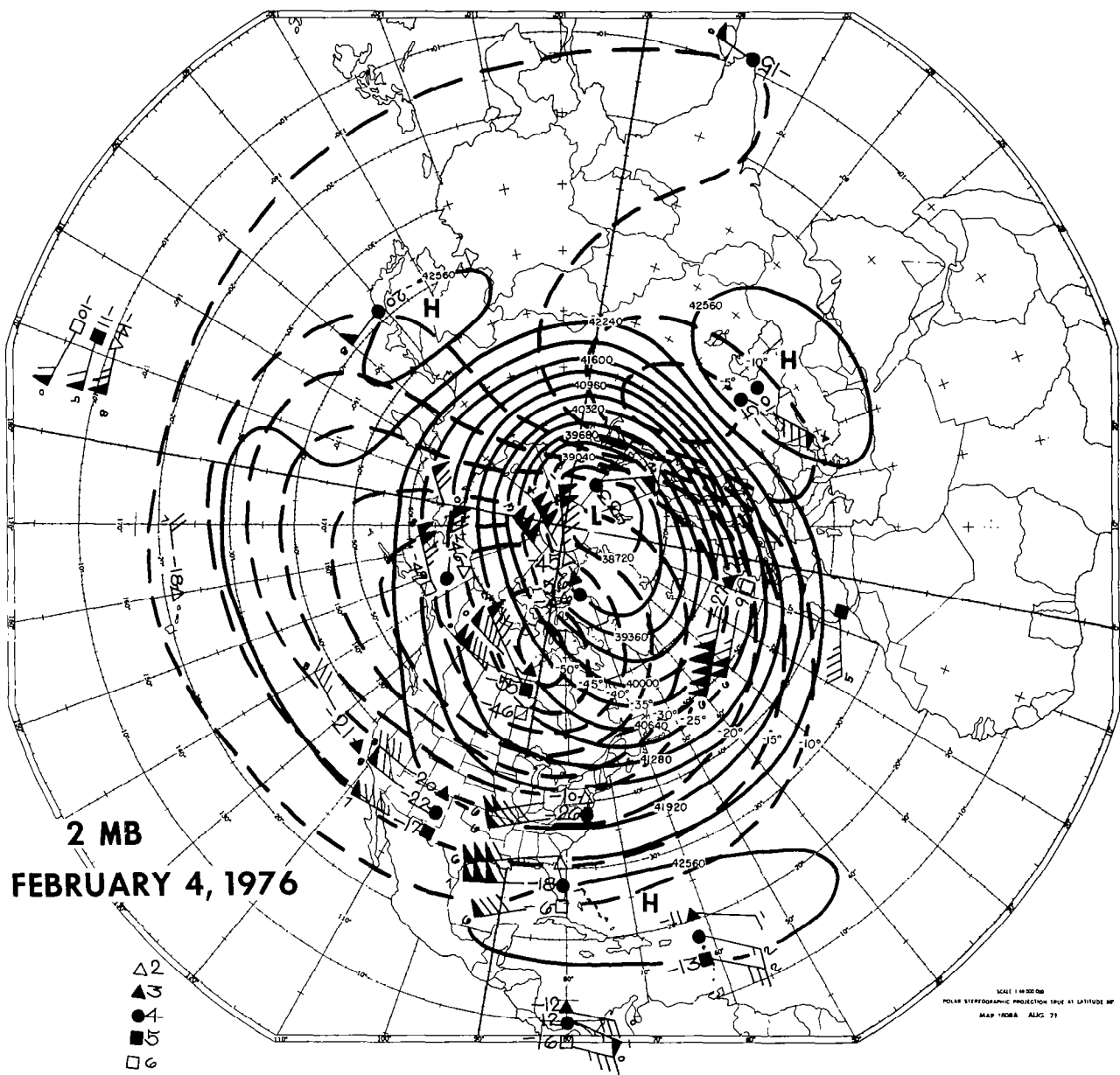


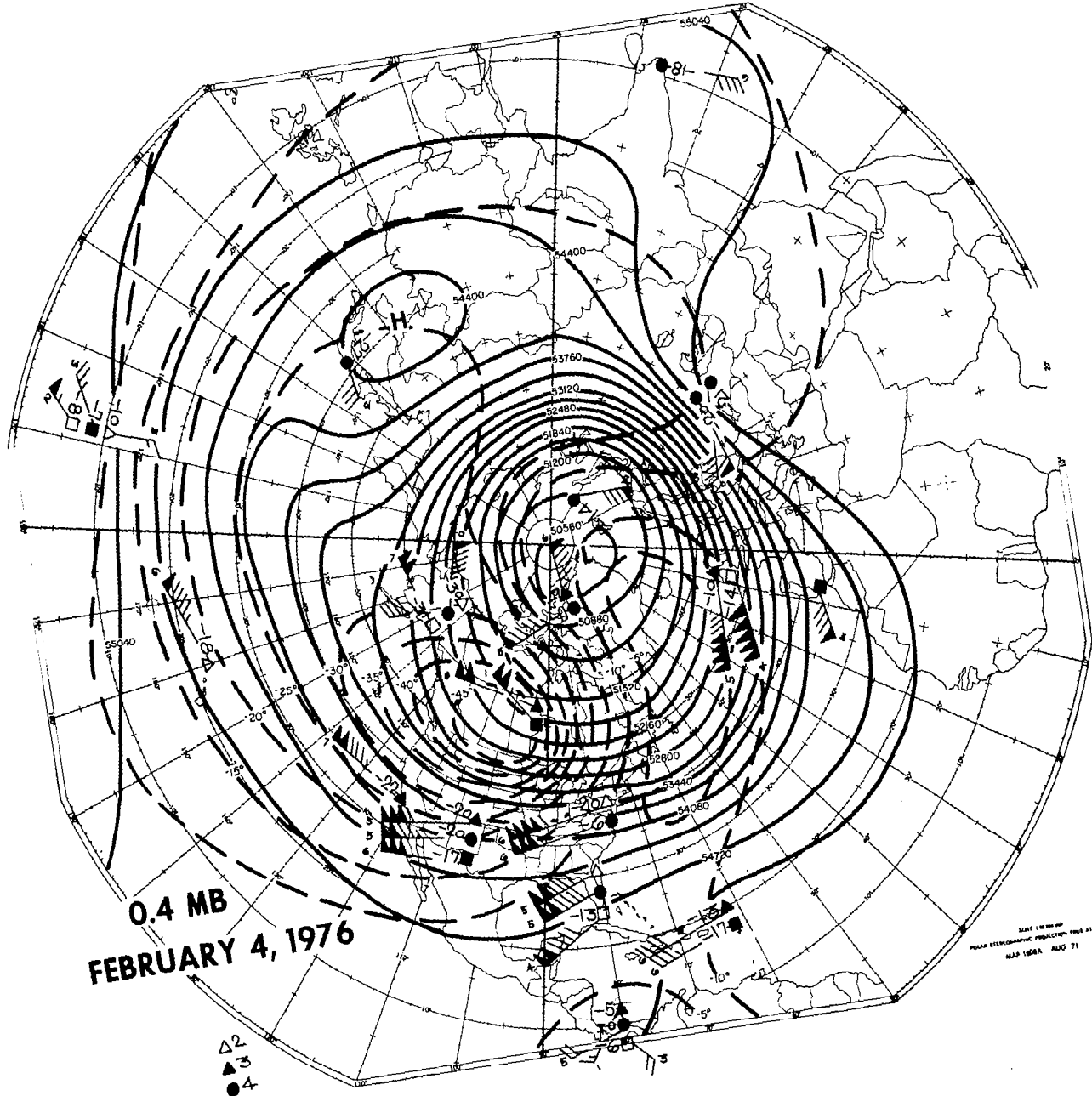










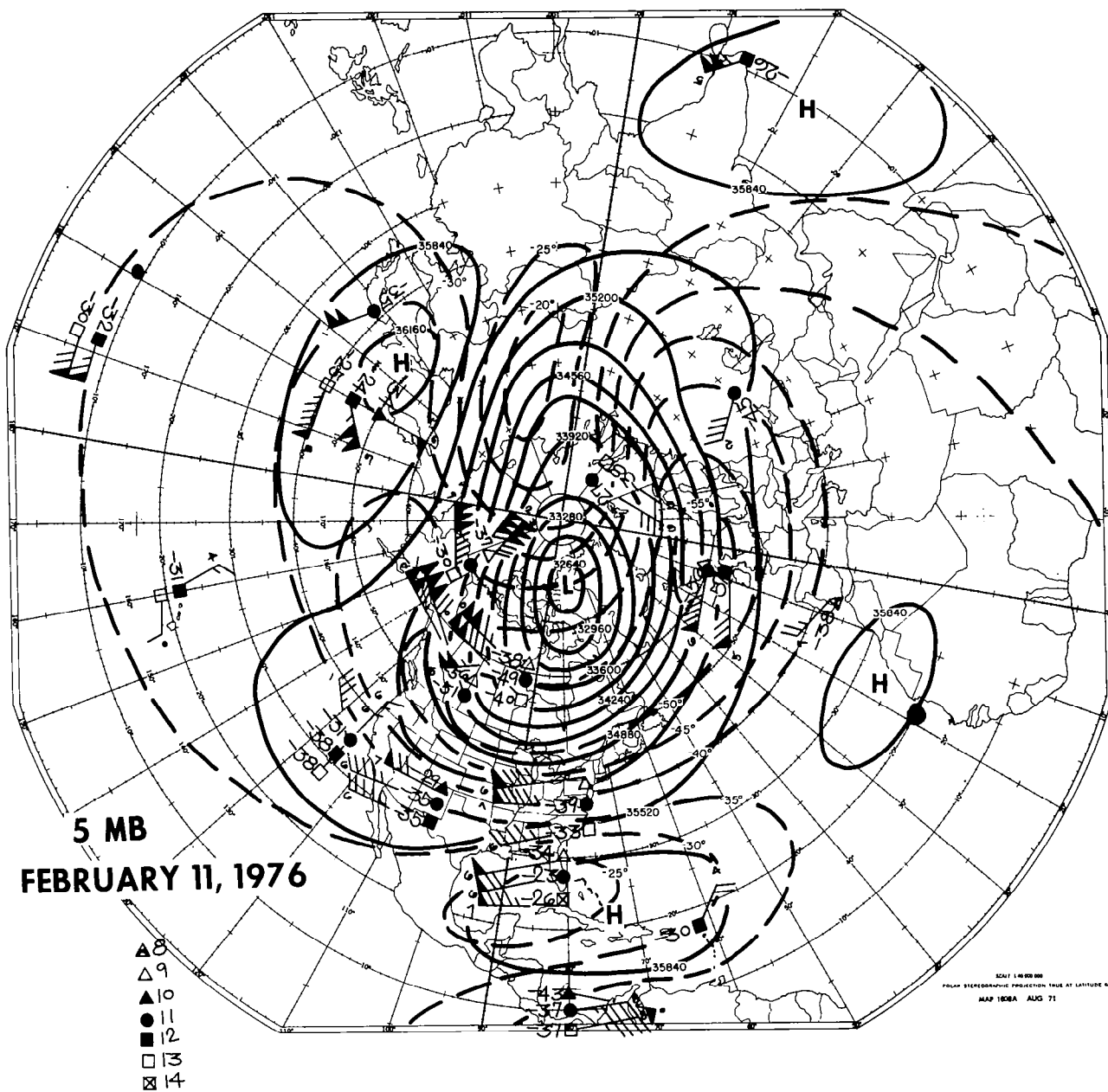


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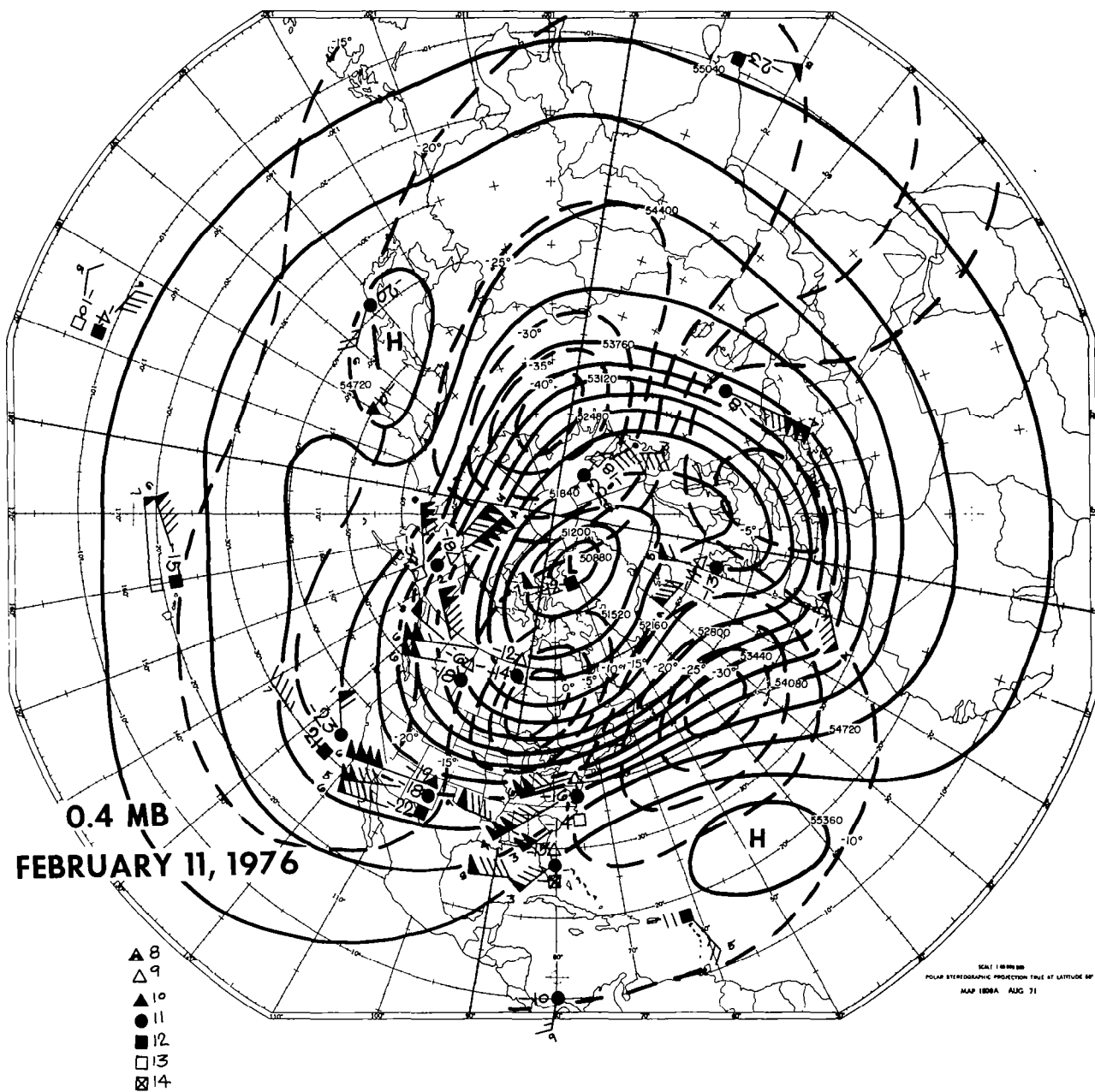
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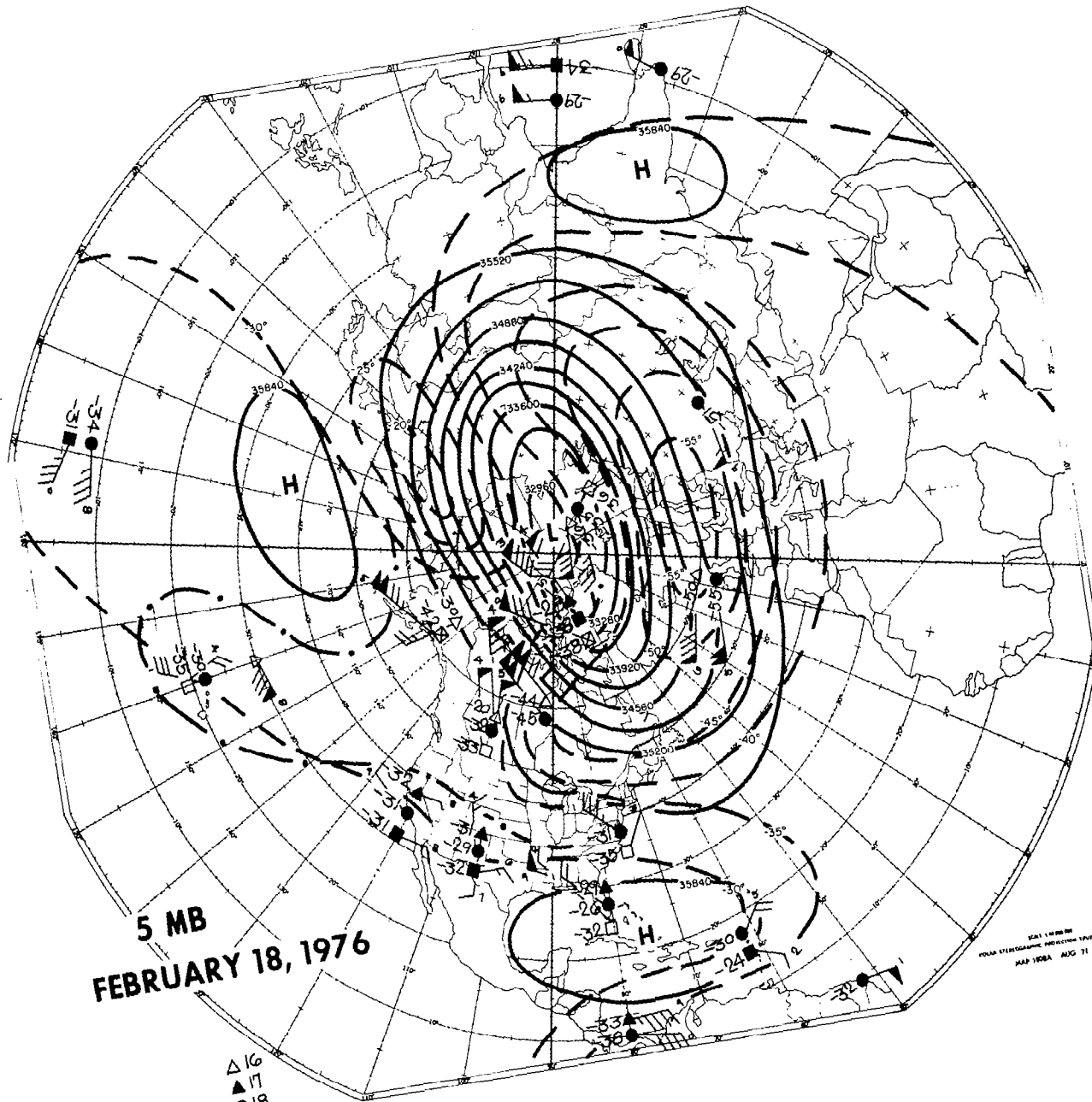
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POLAR STEREOGRAPHIC PROJECTION TRUE TO LATITUDE 90°  
MAP 1608A AUG 71

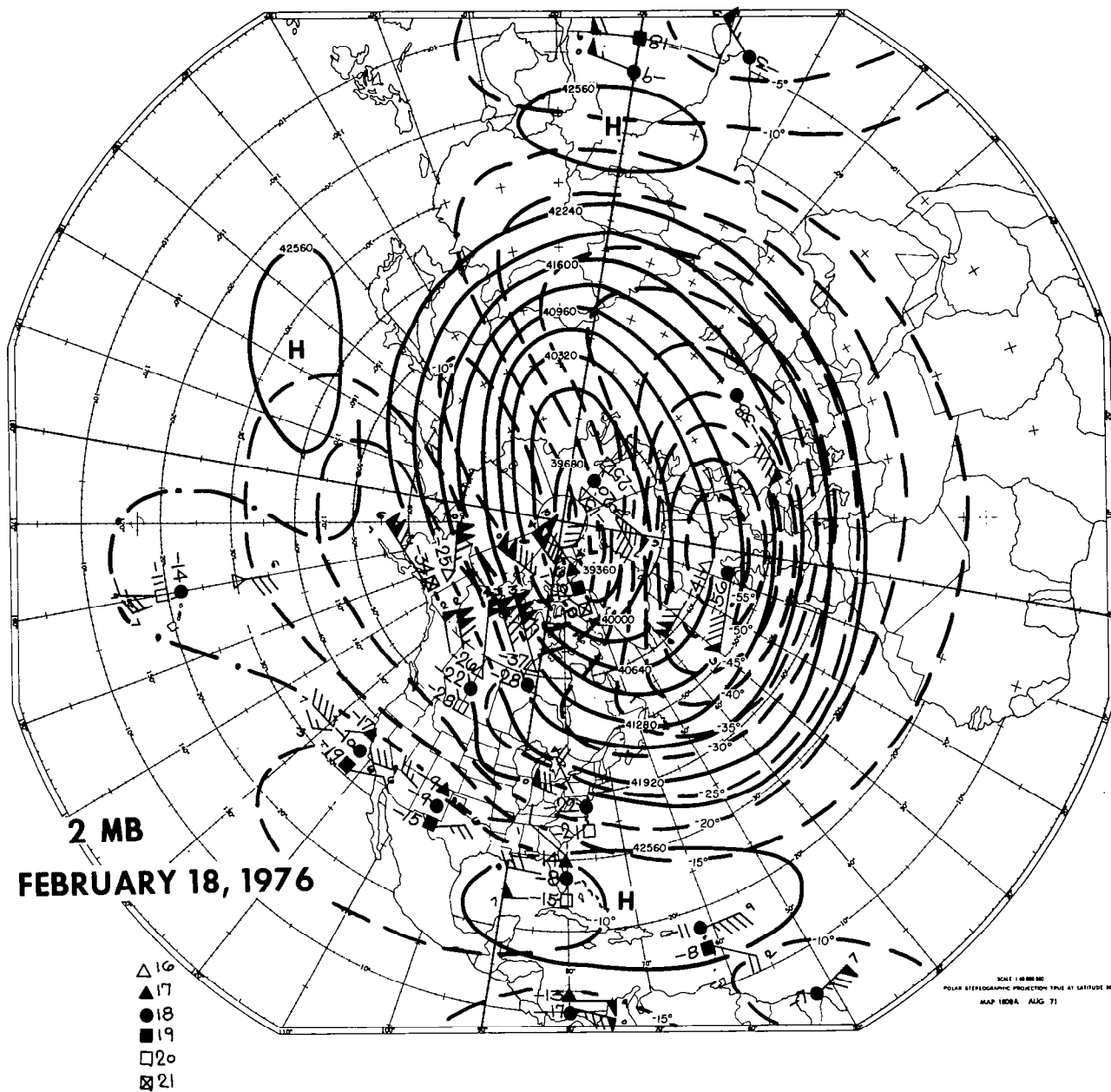


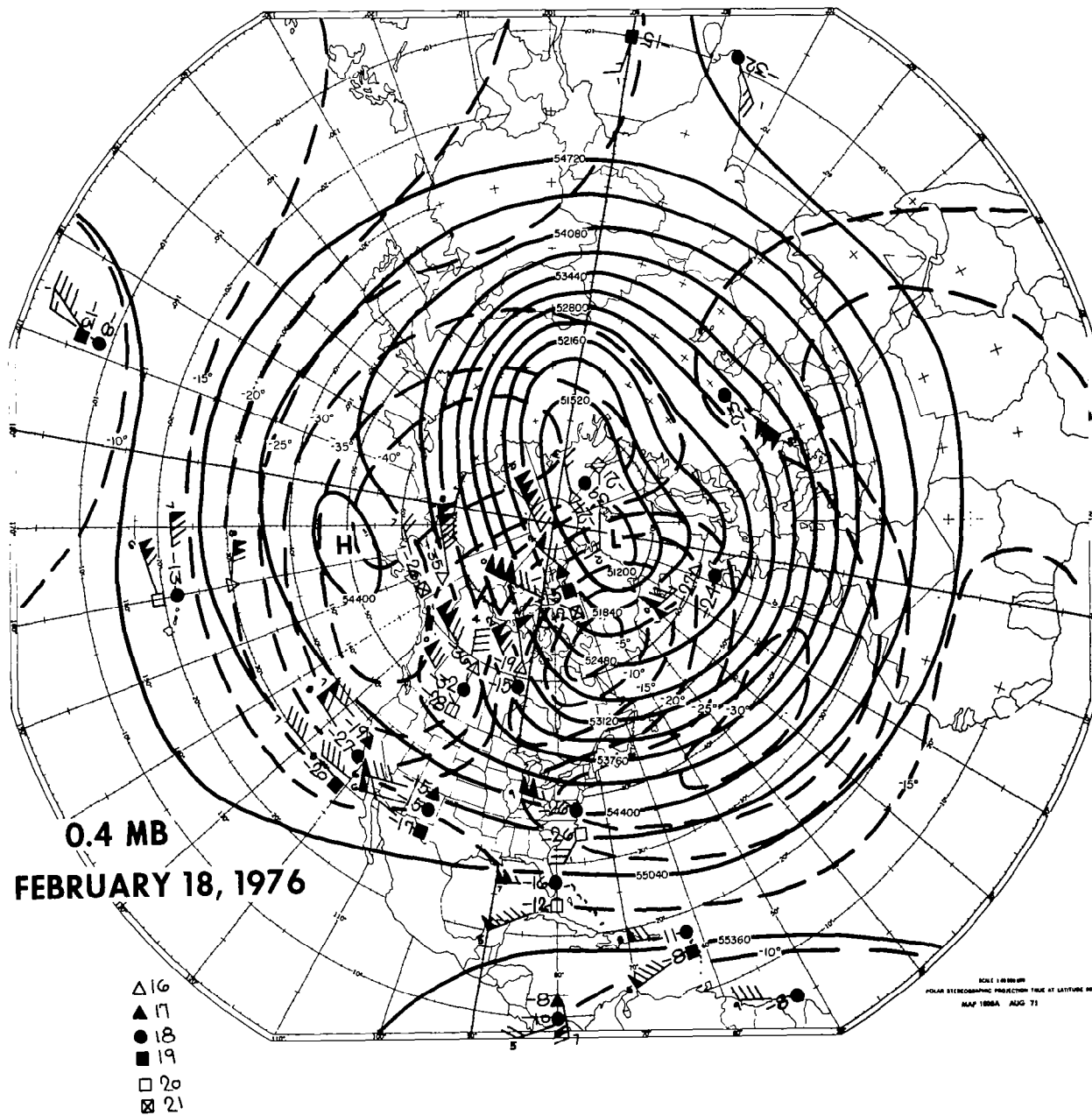


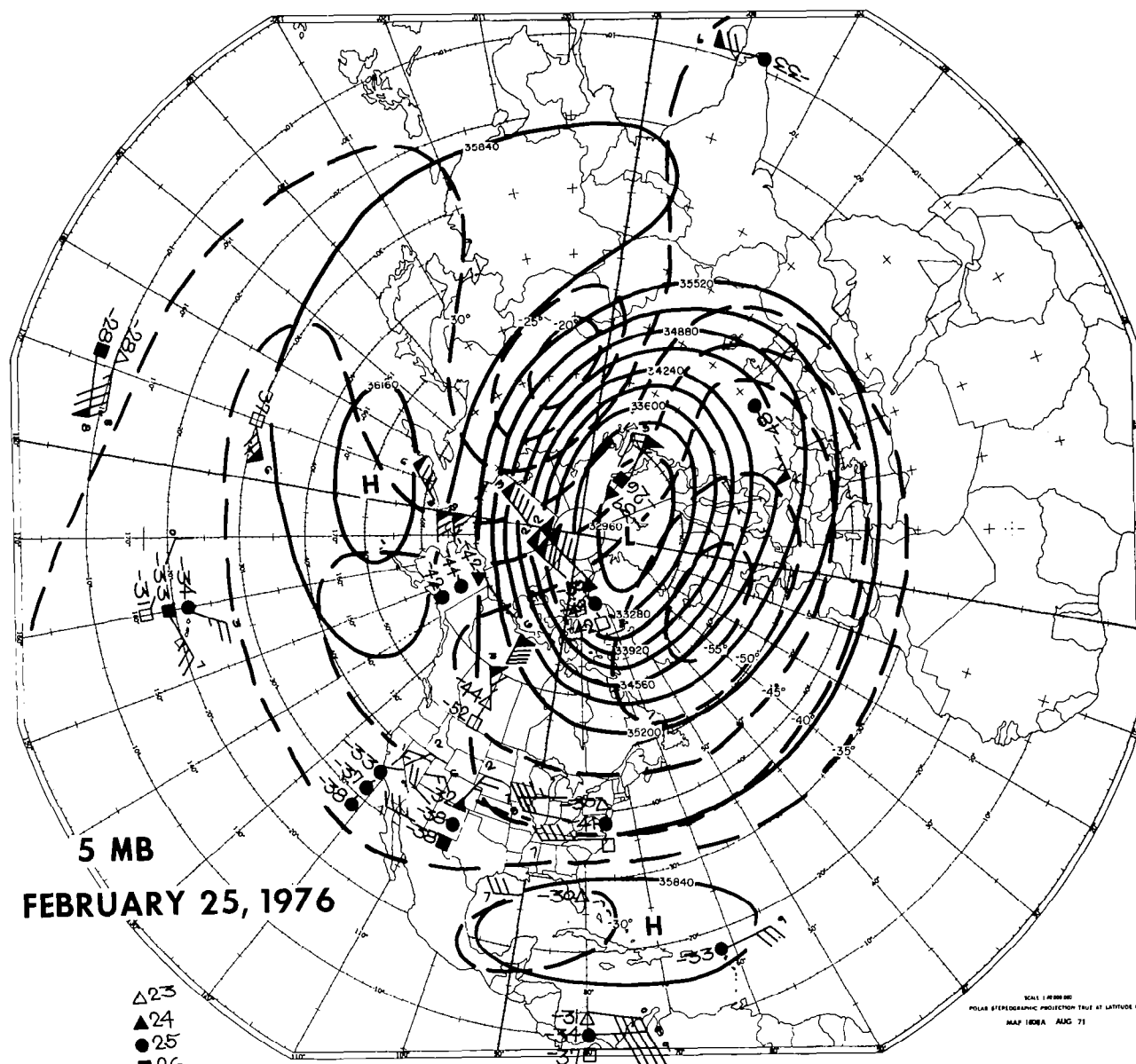


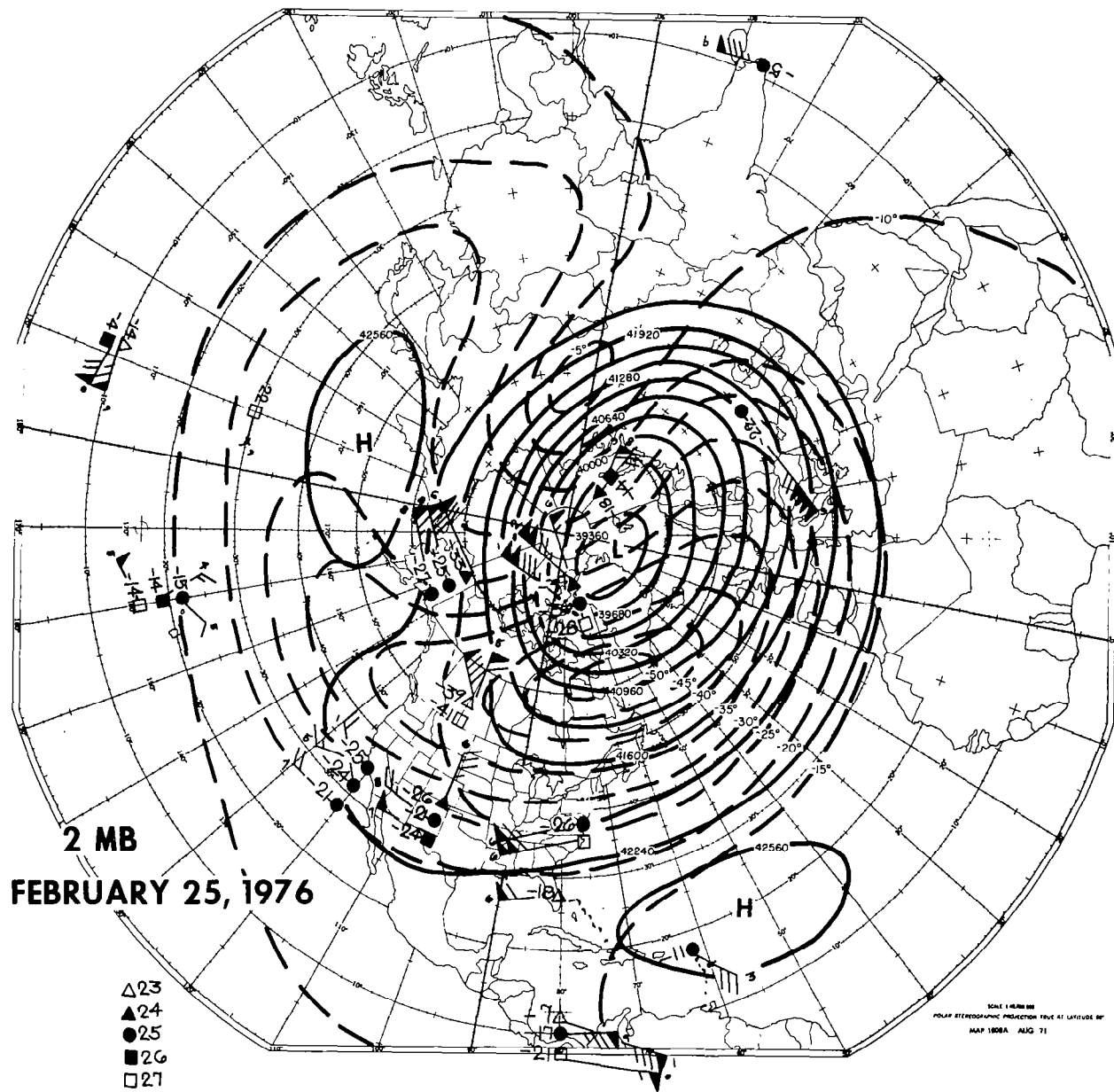




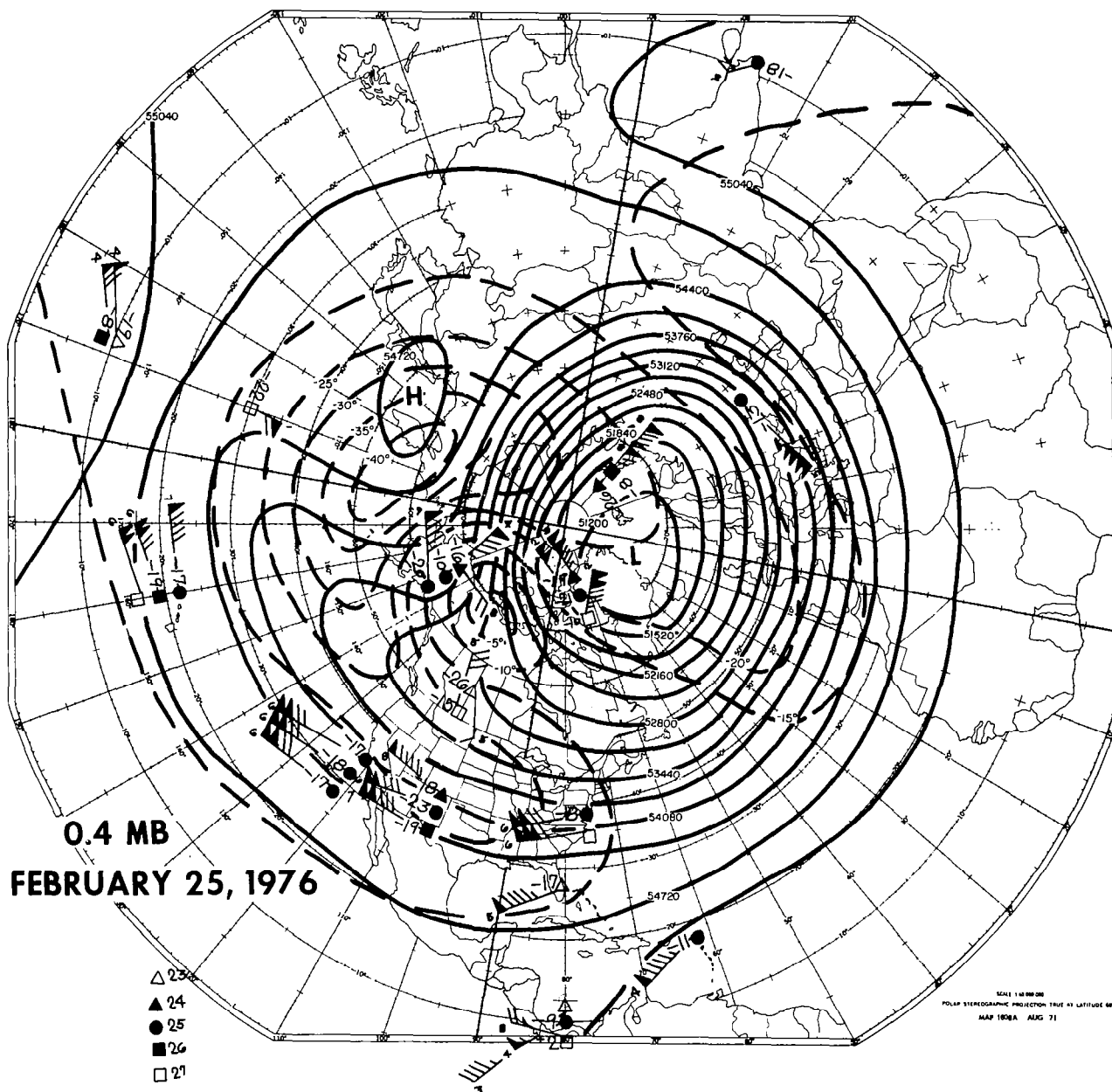


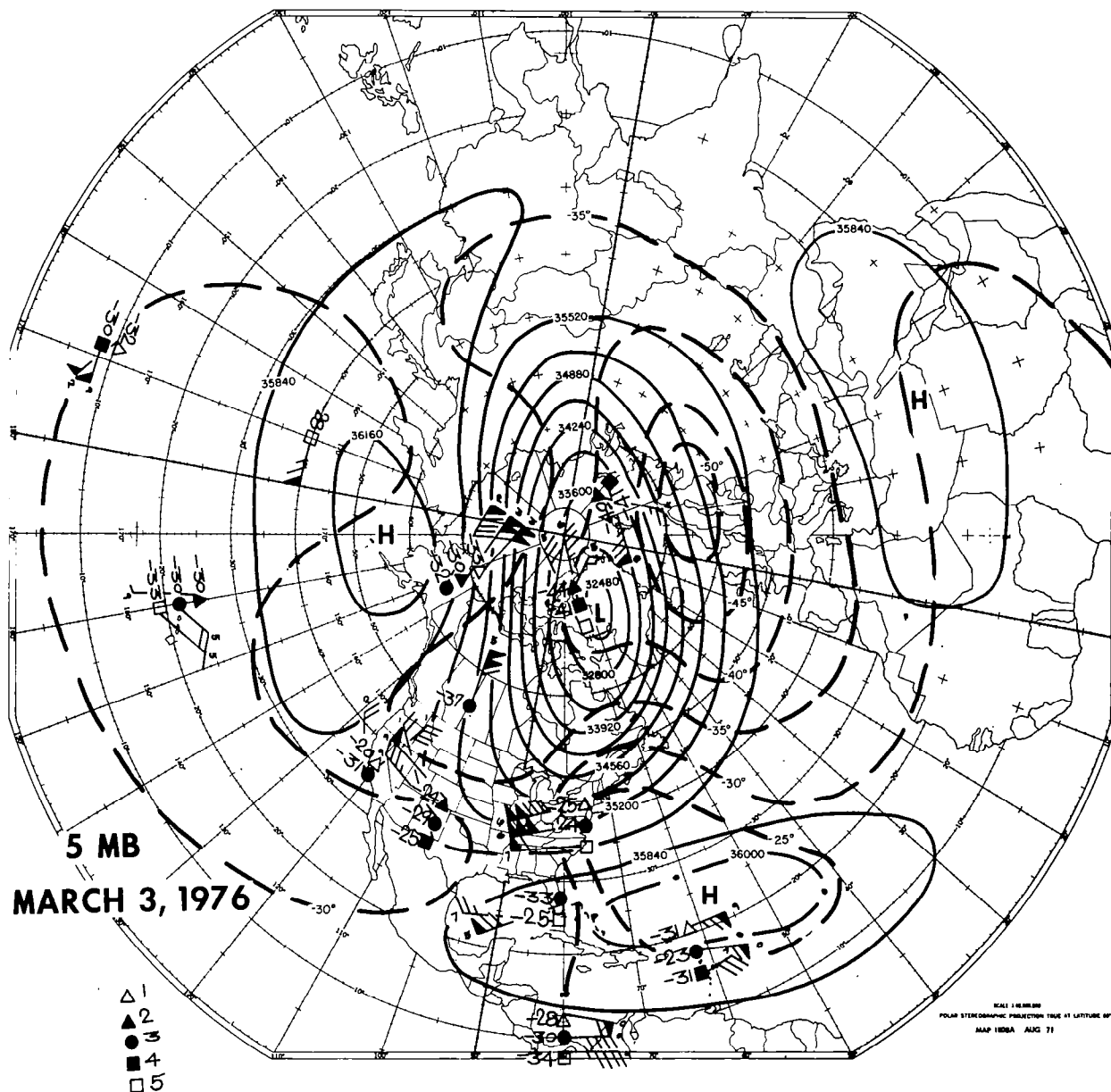


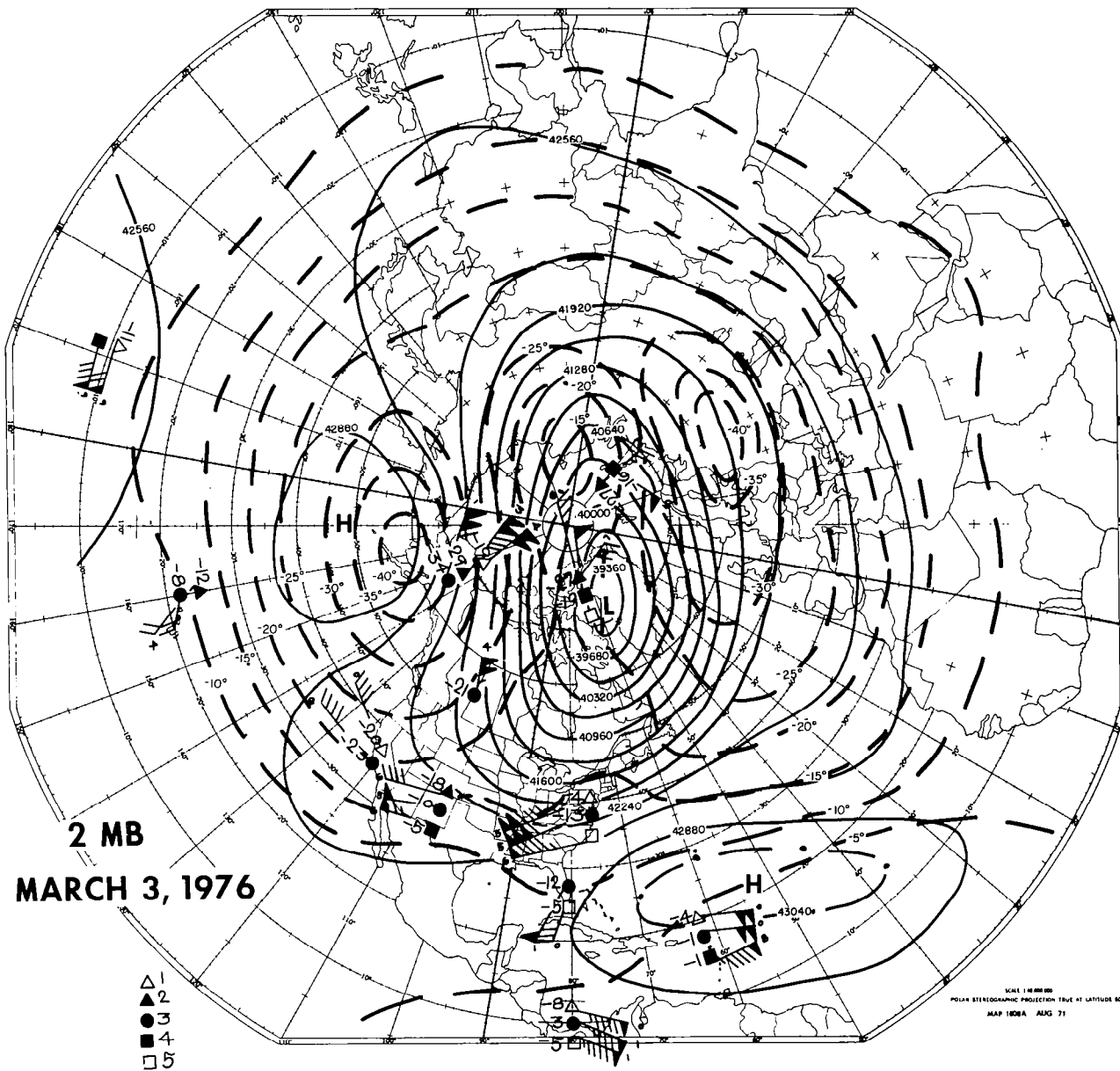


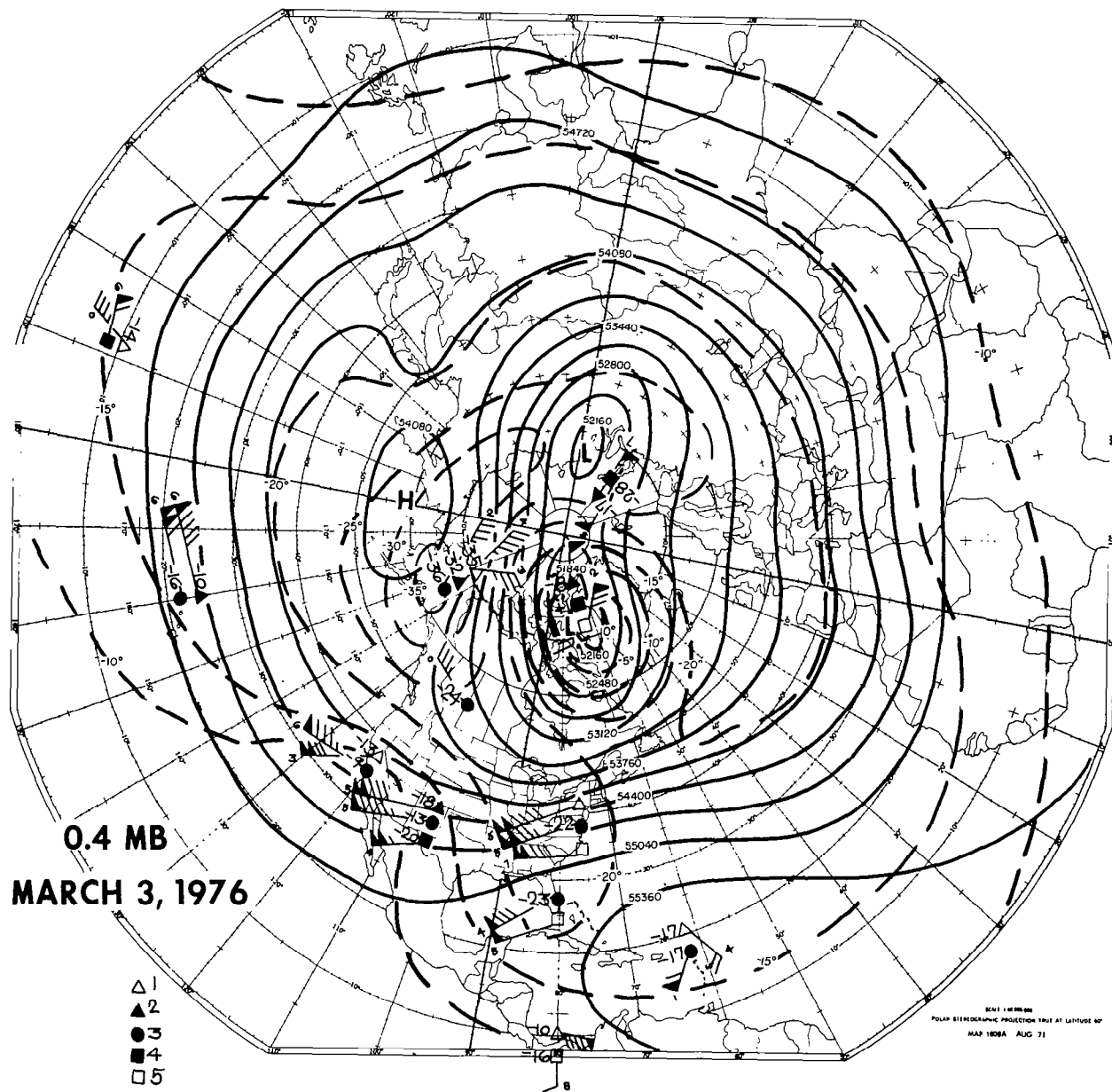


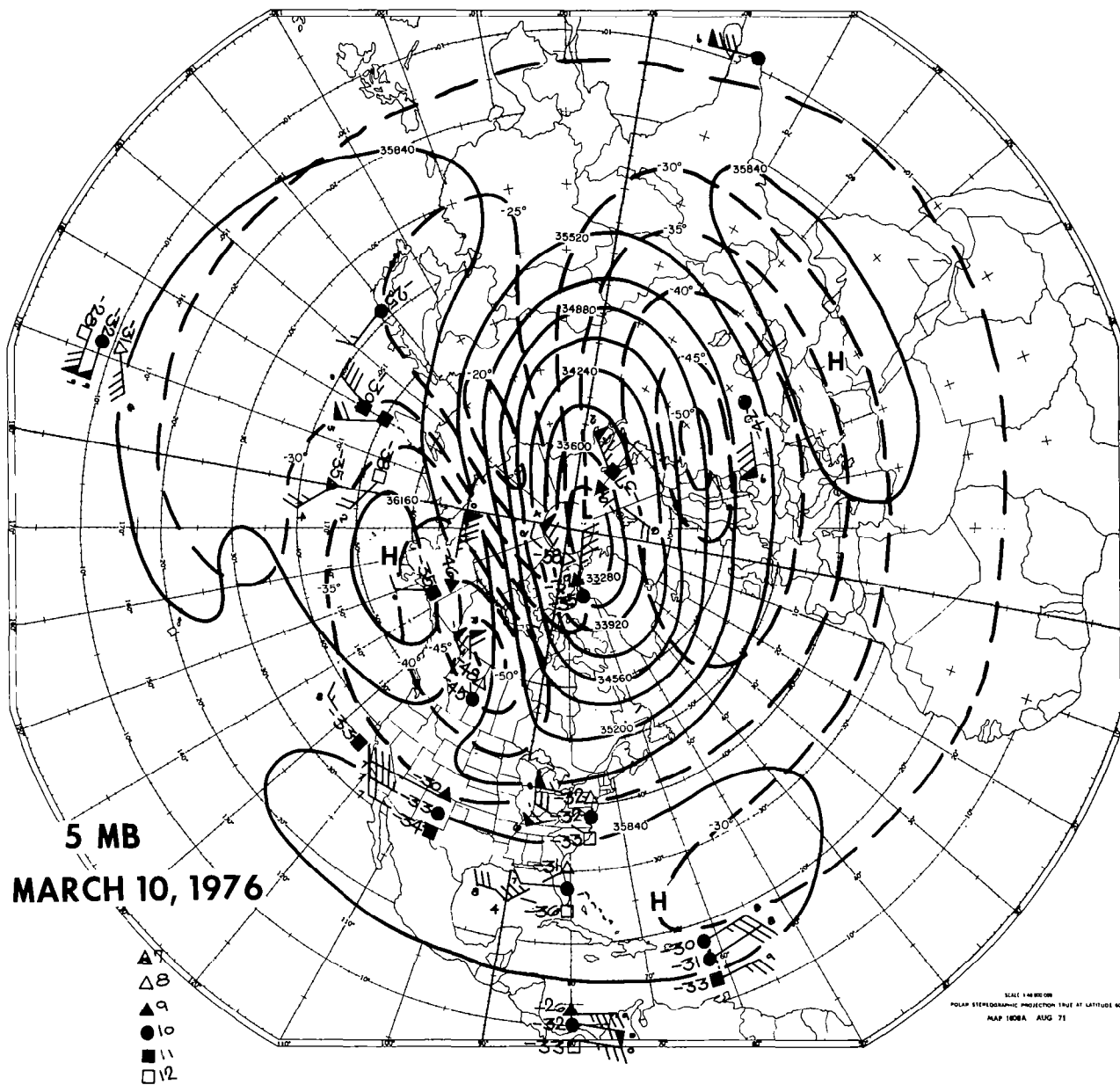




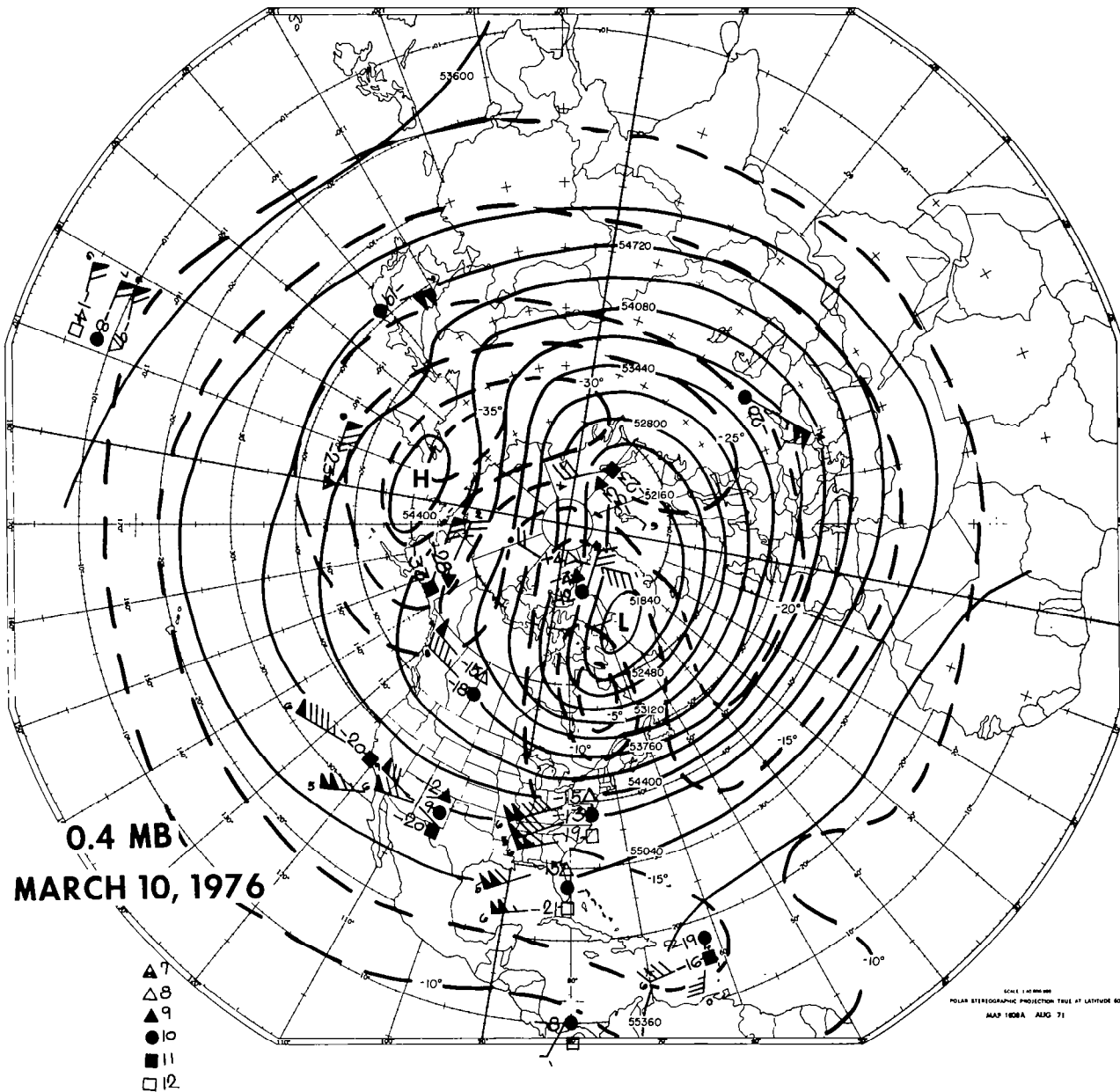


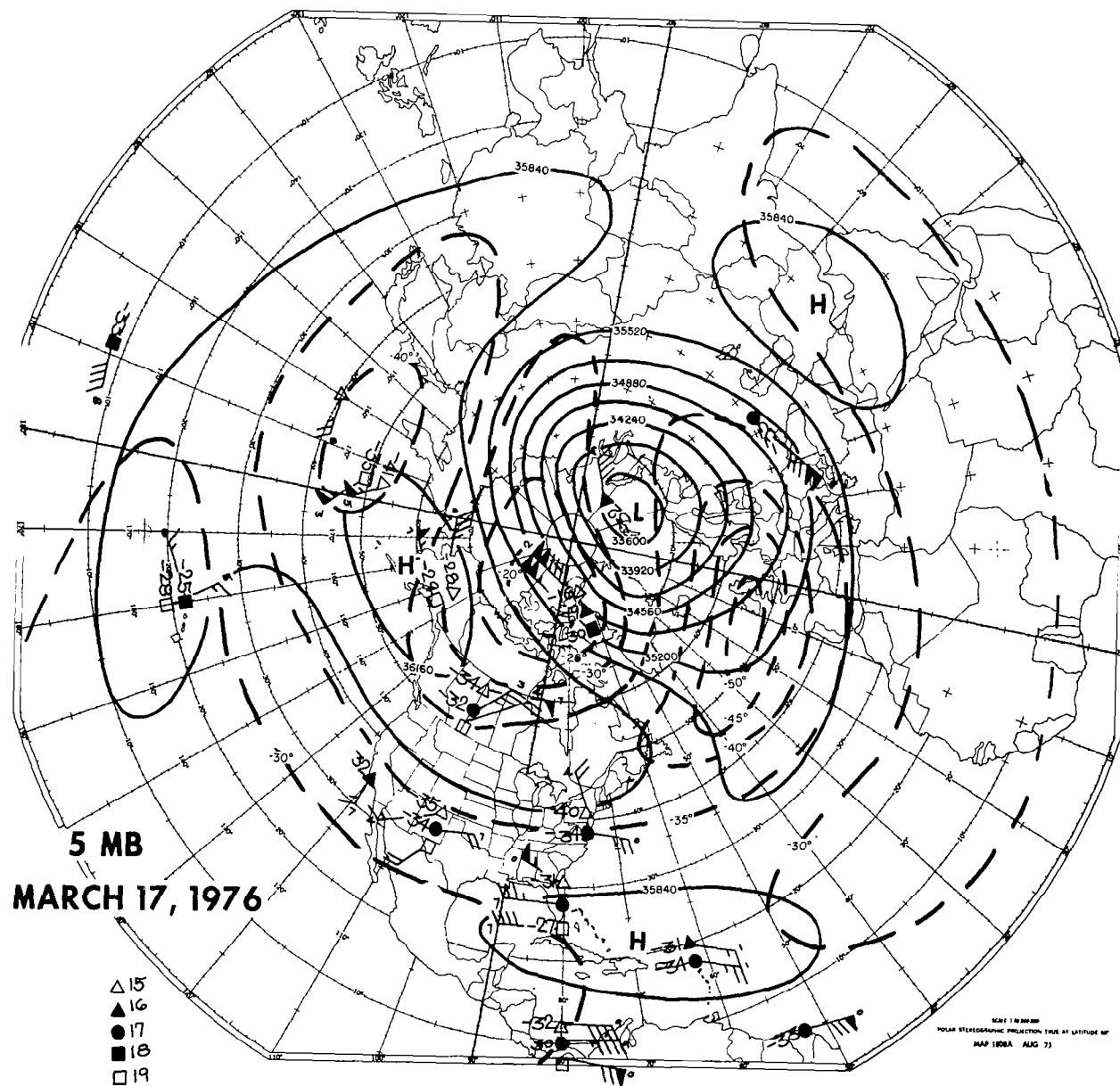




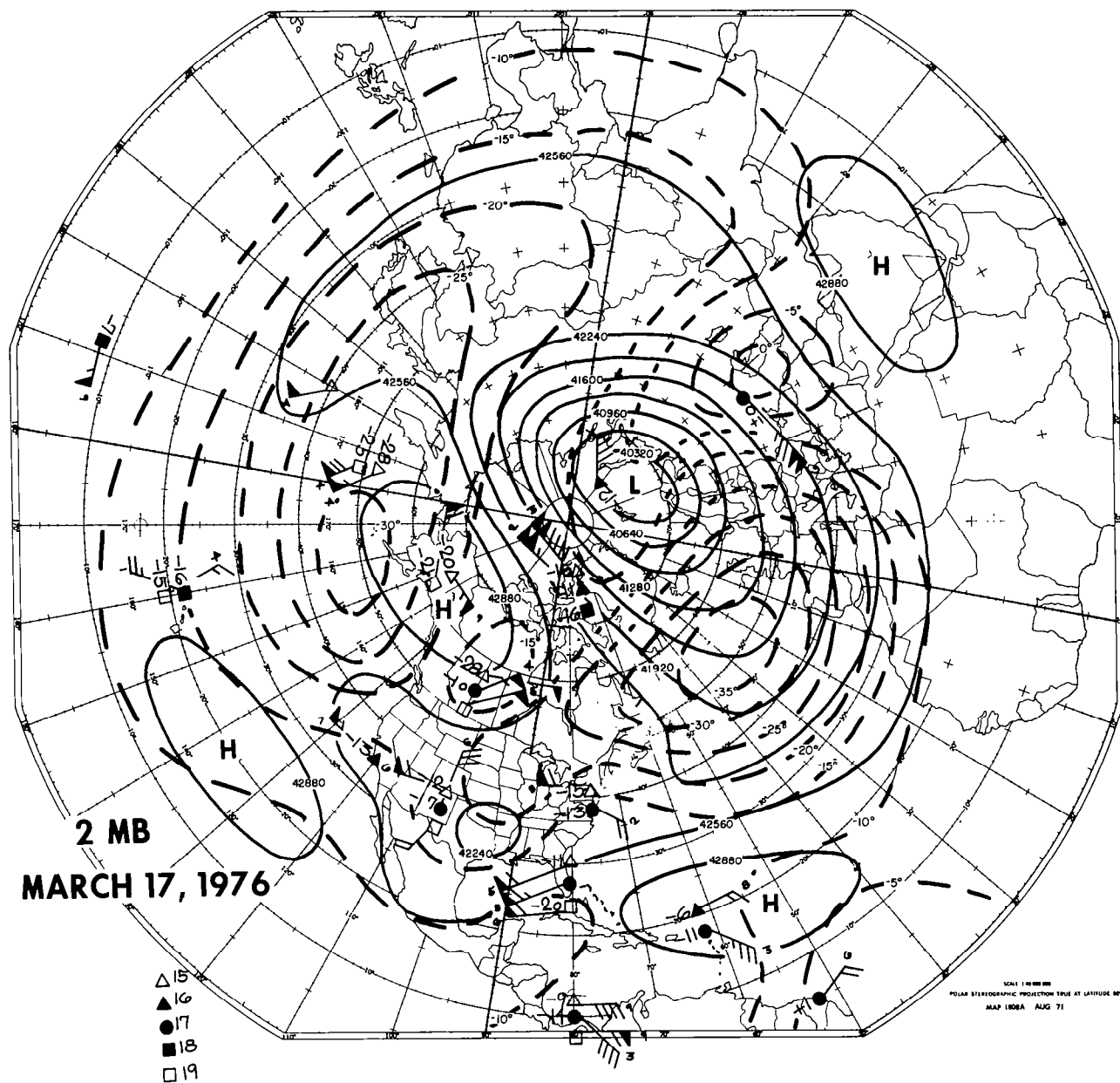


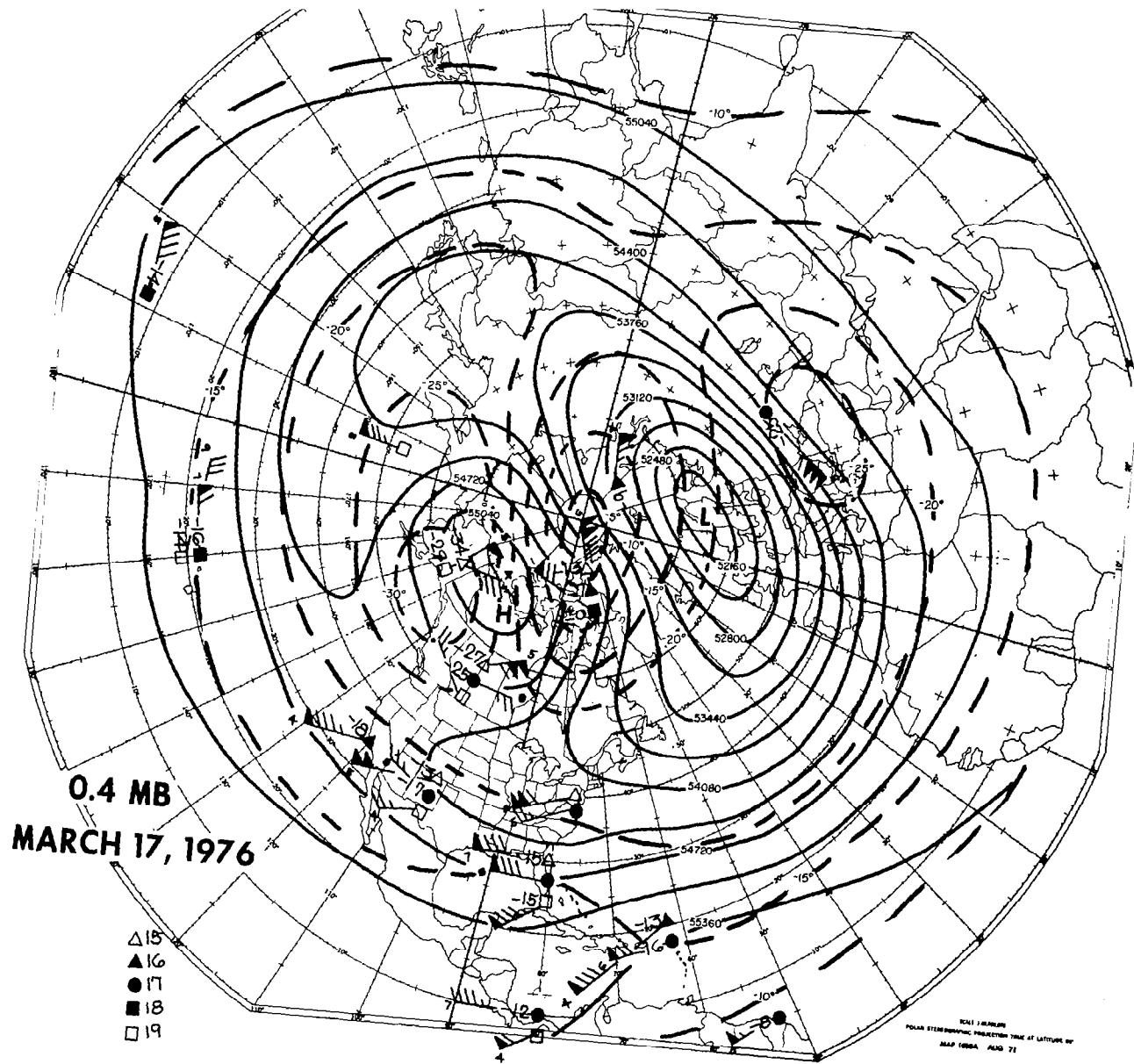


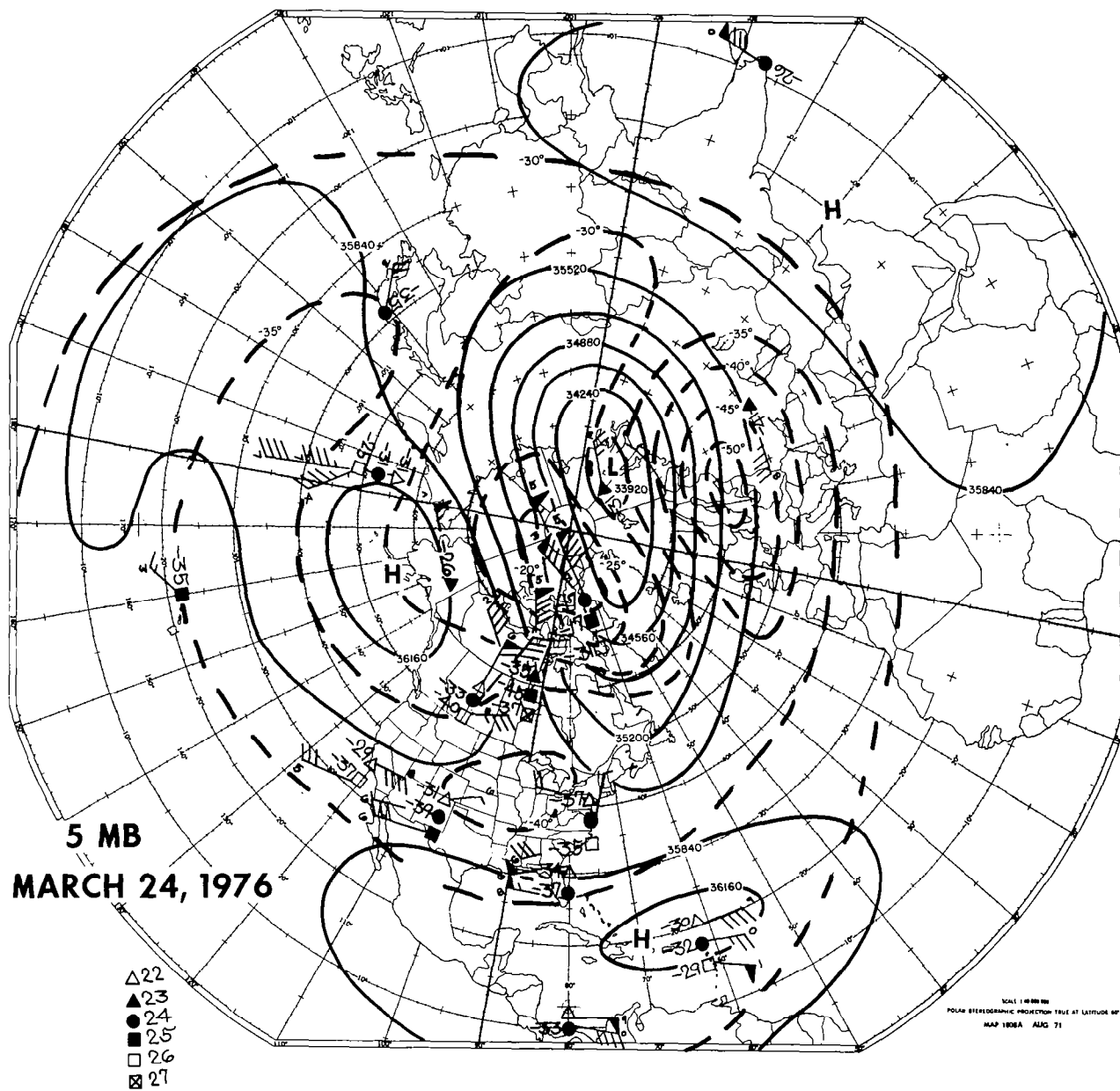


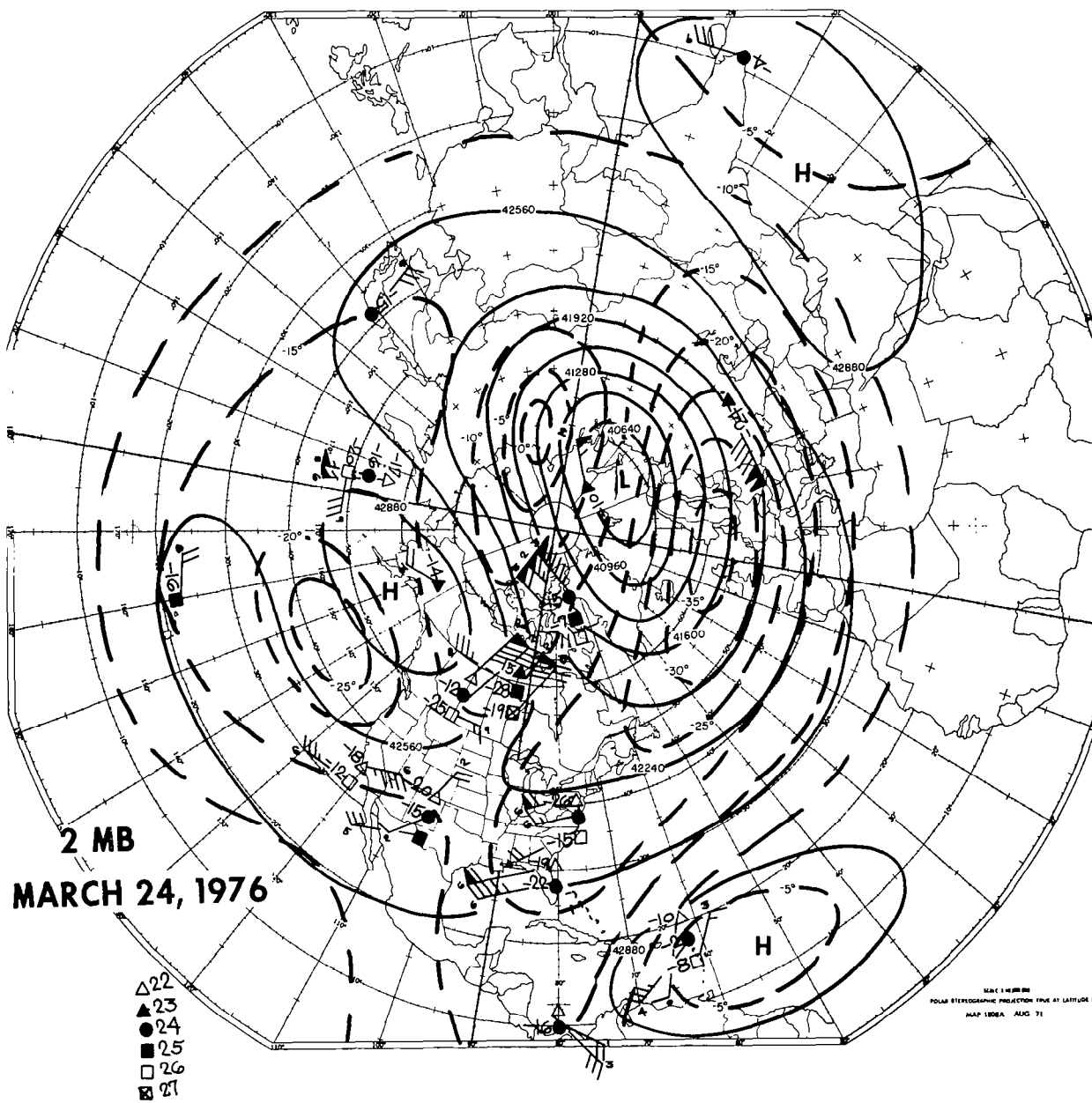


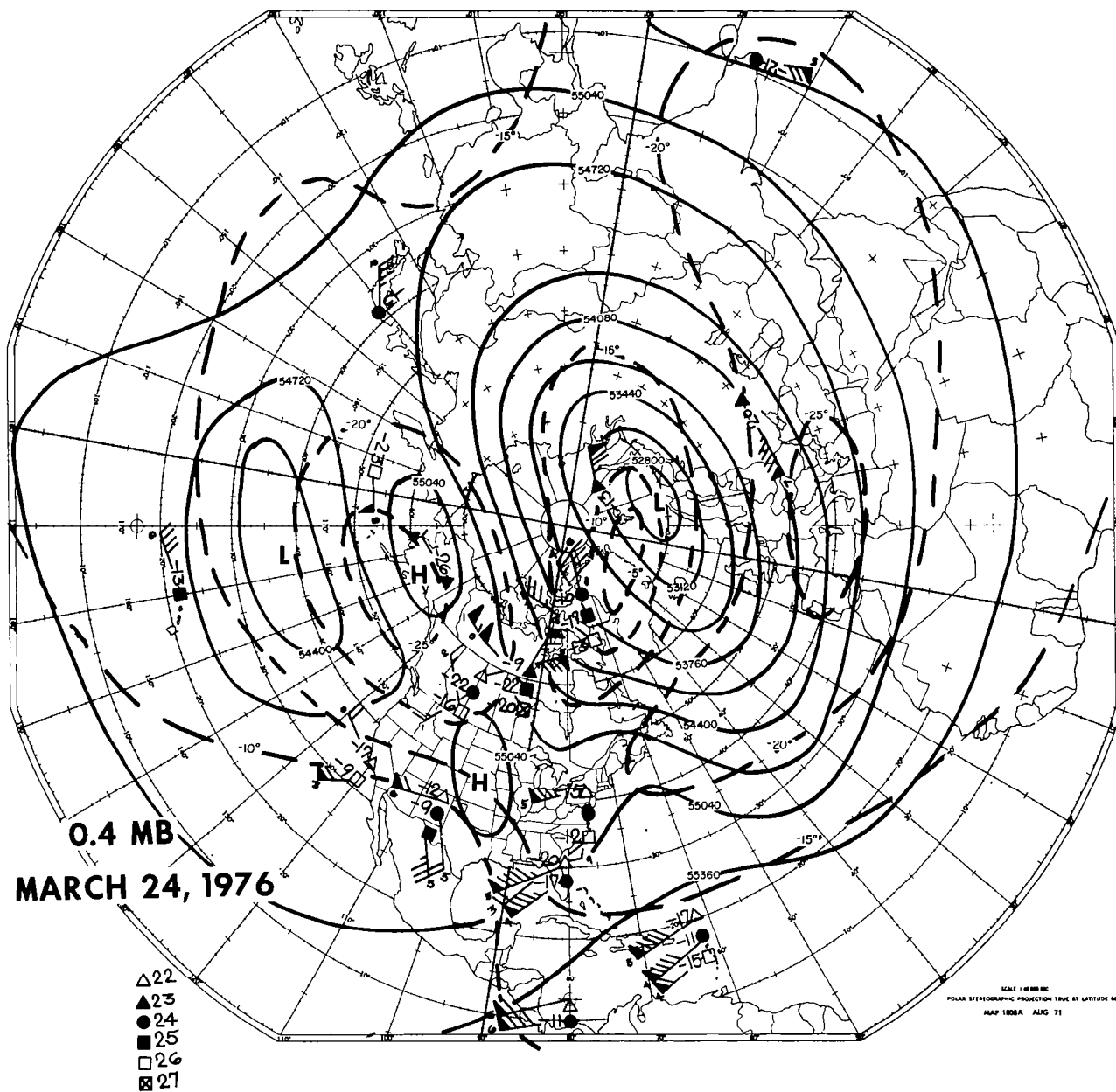


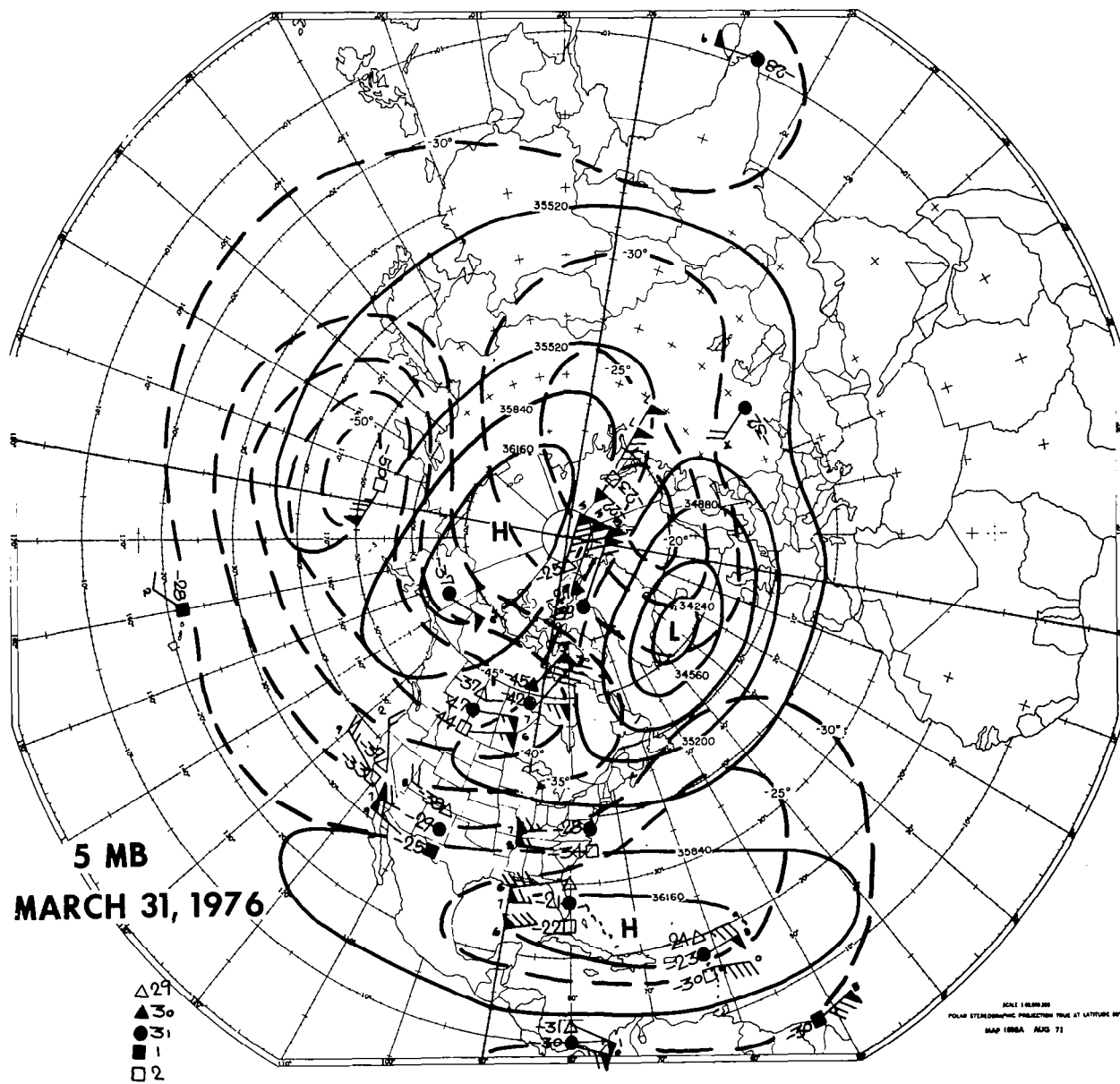




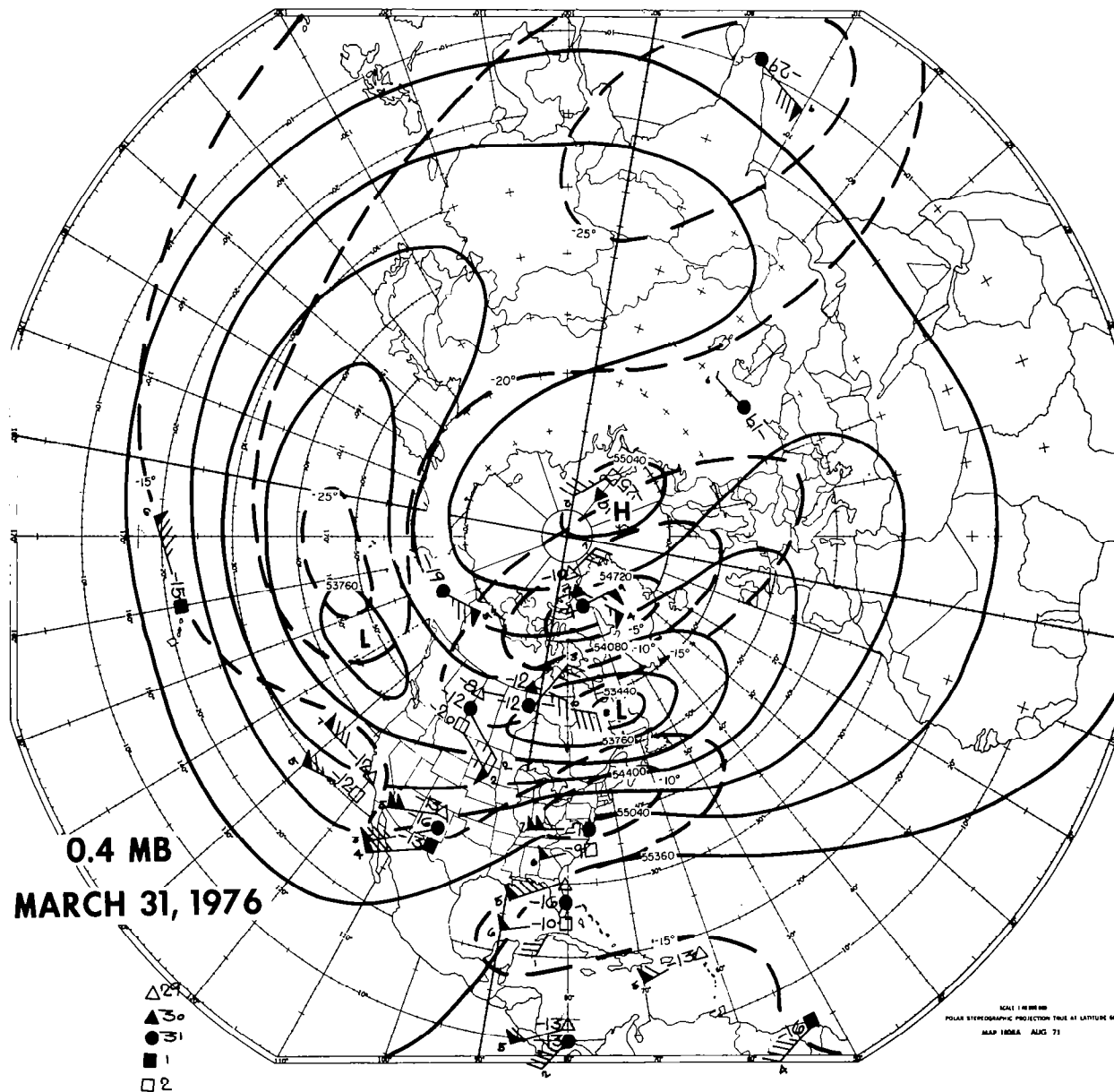




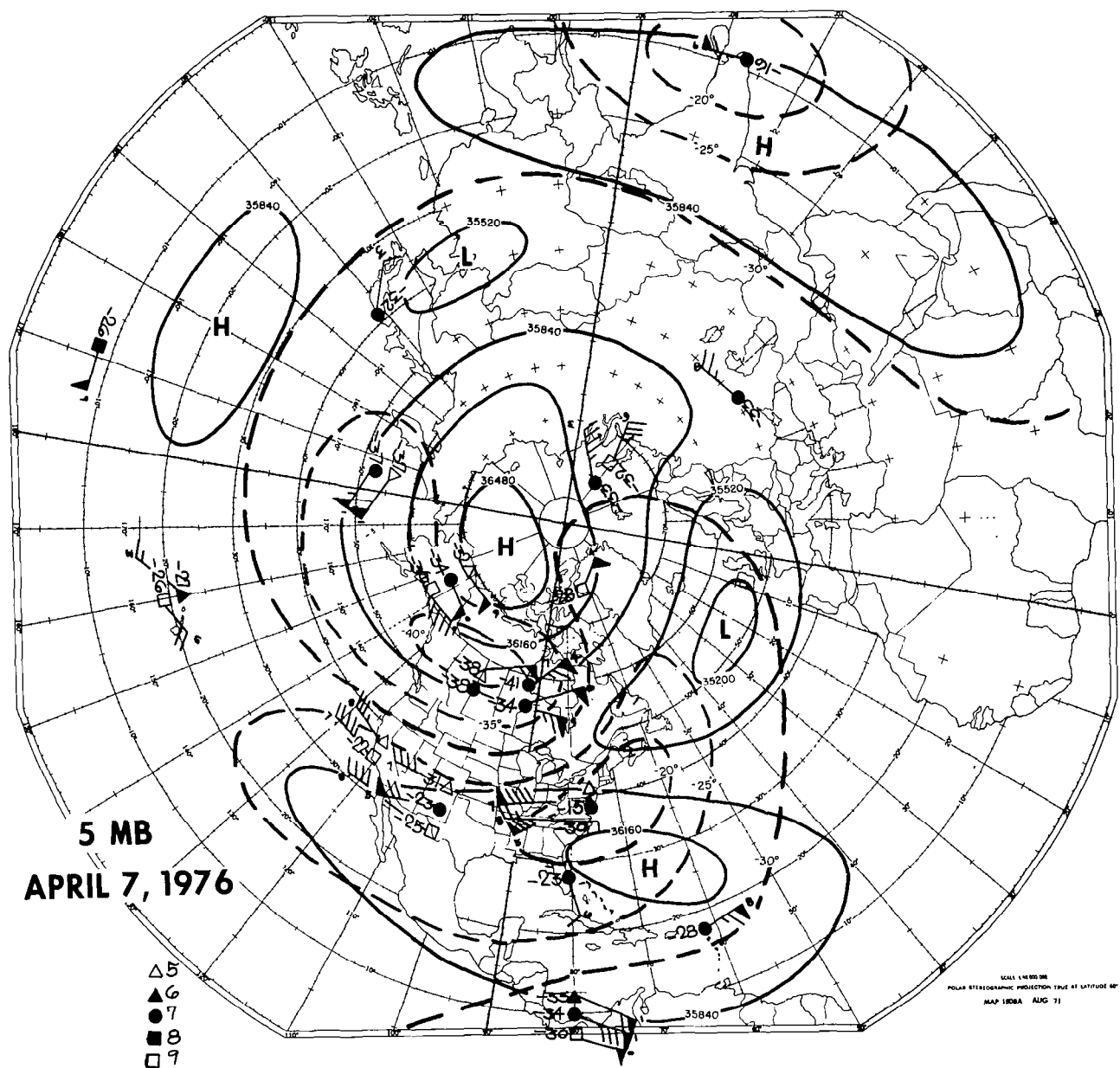


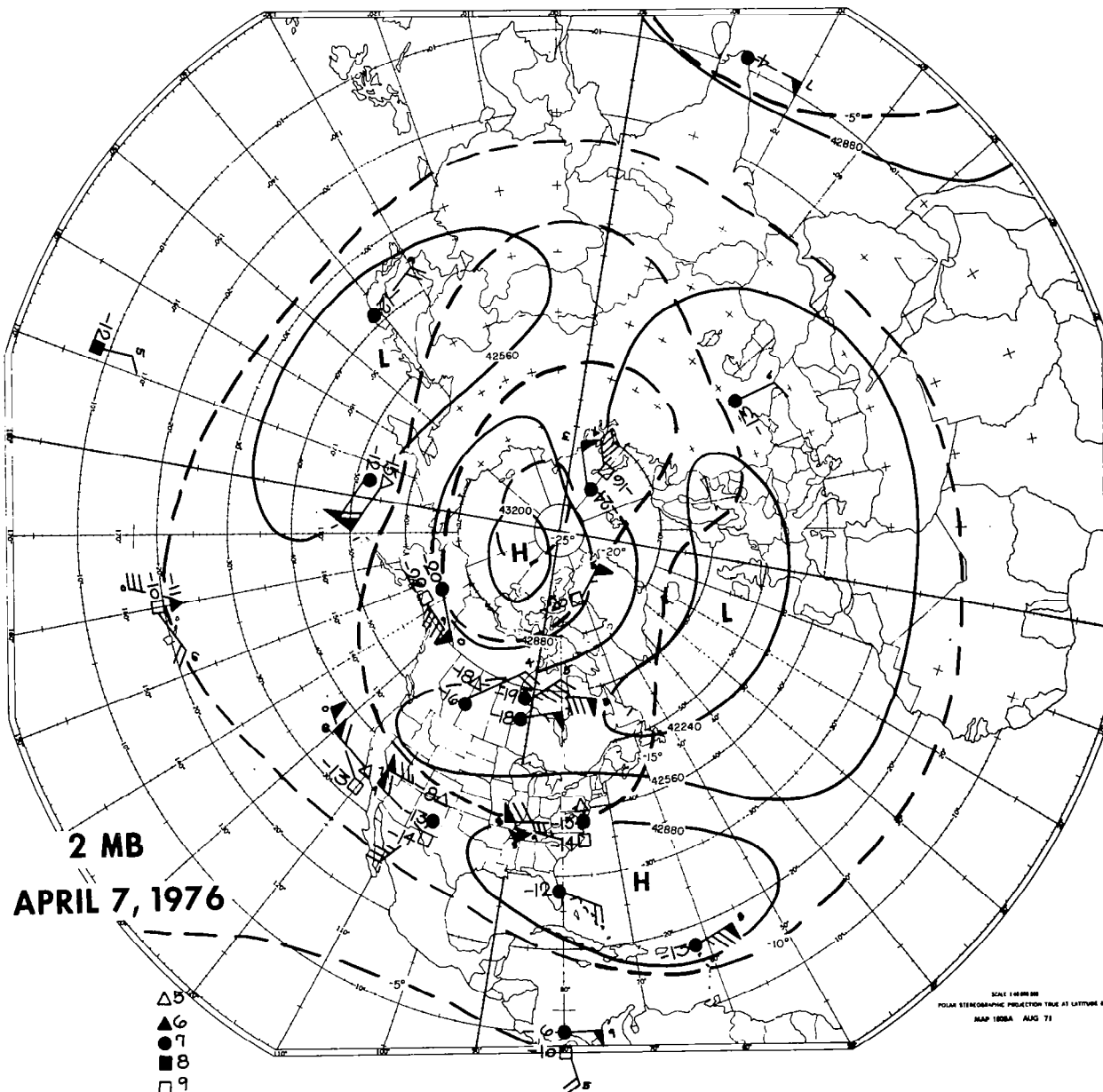




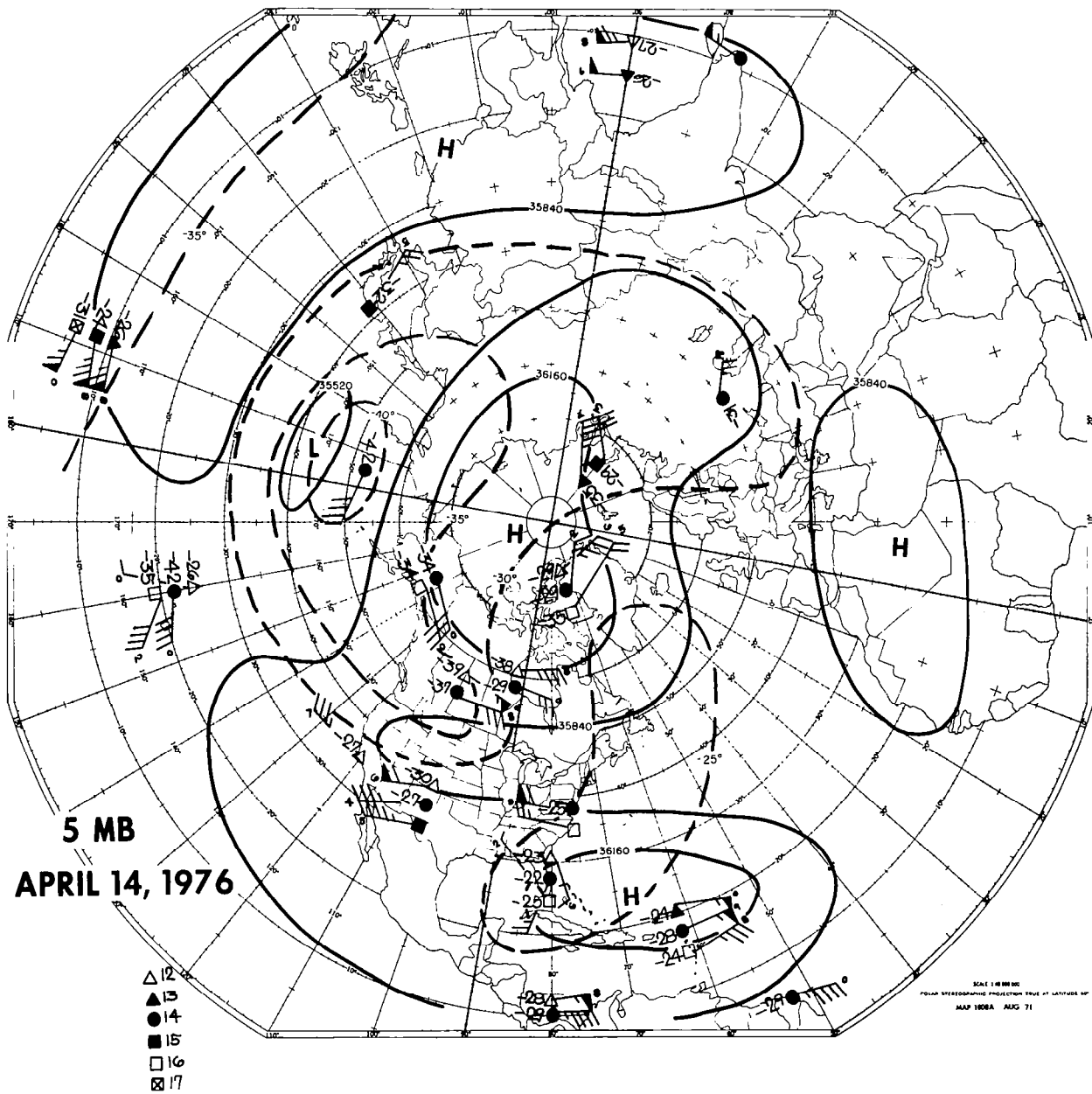


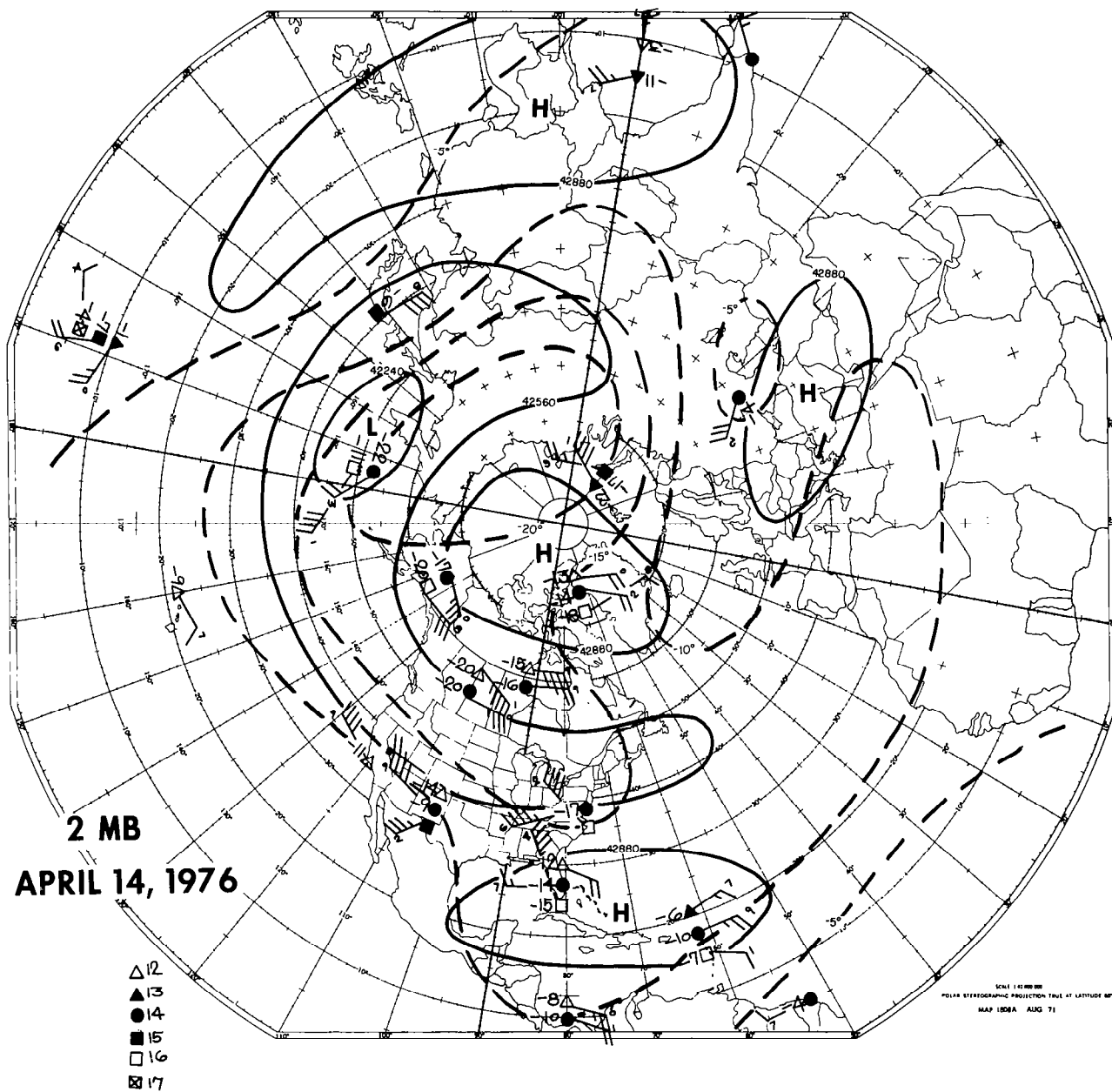


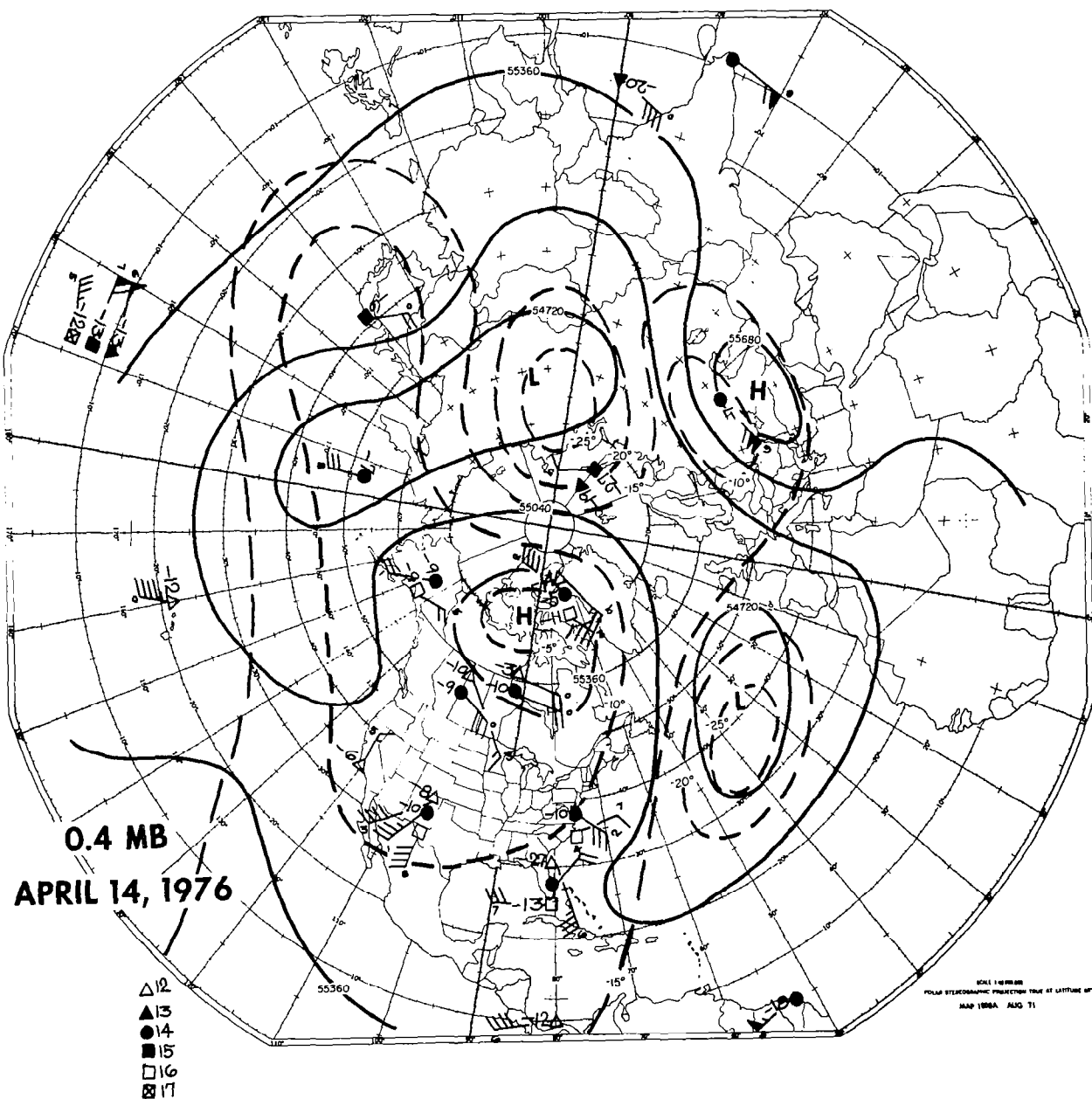


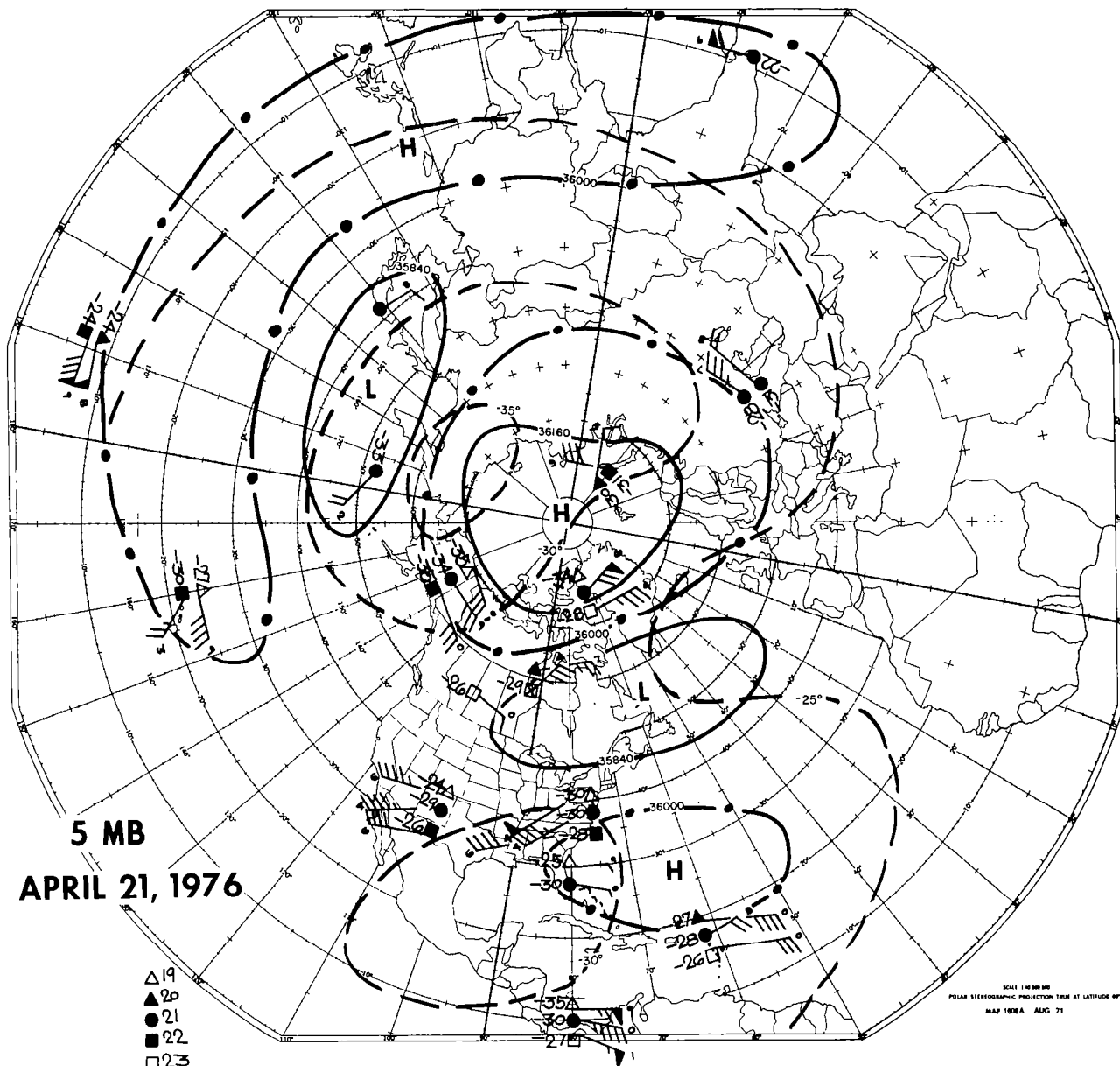


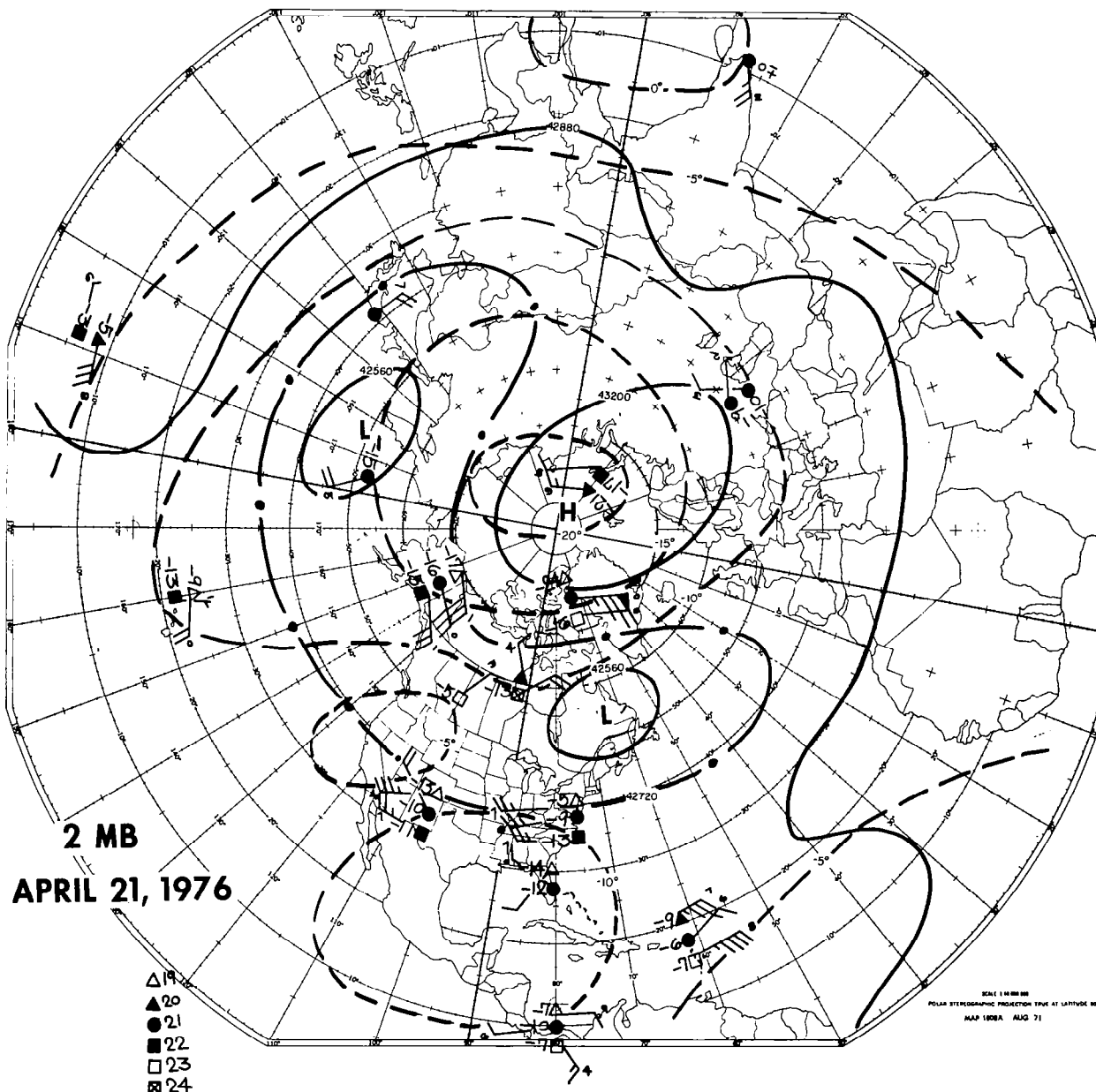




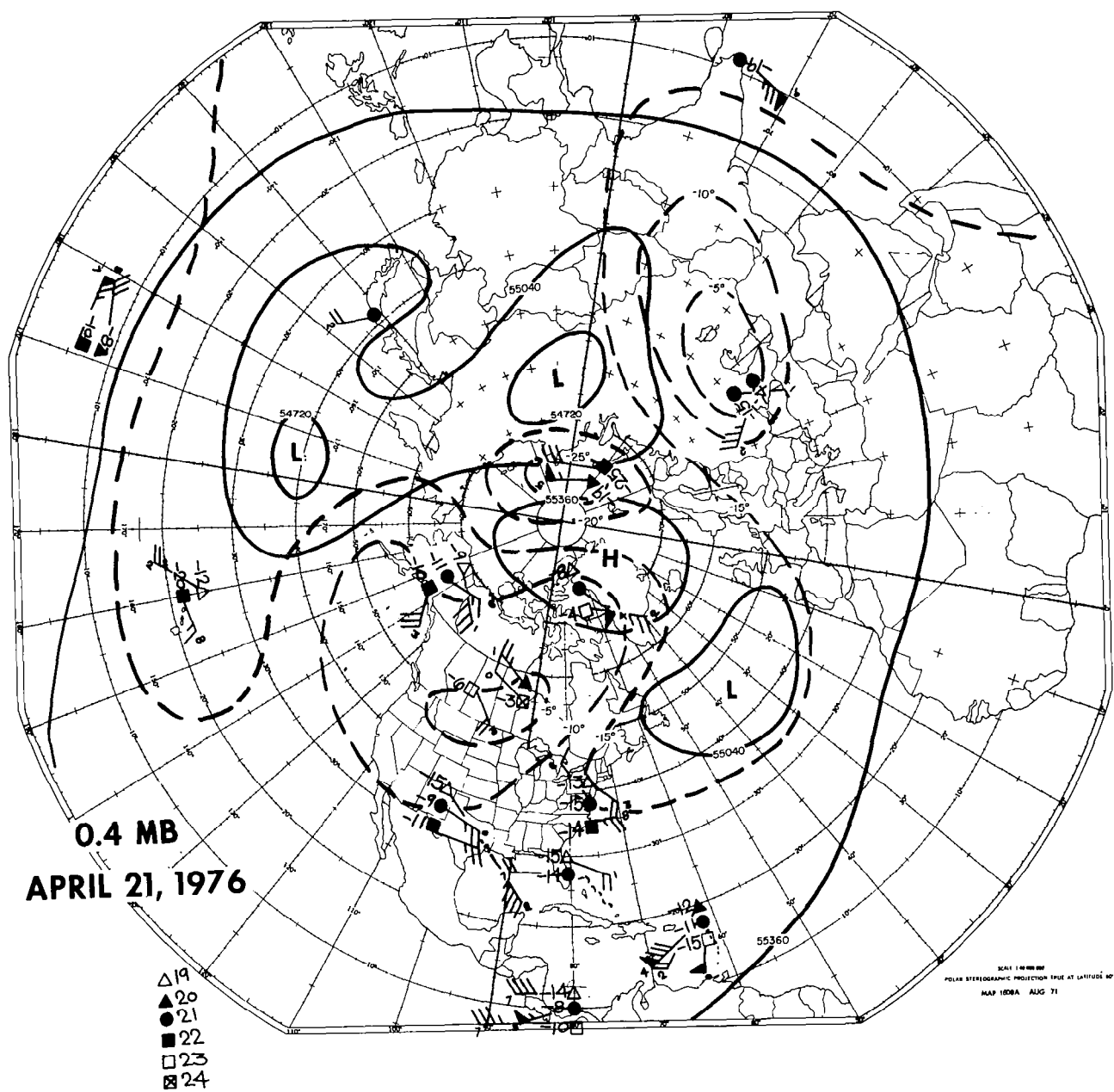


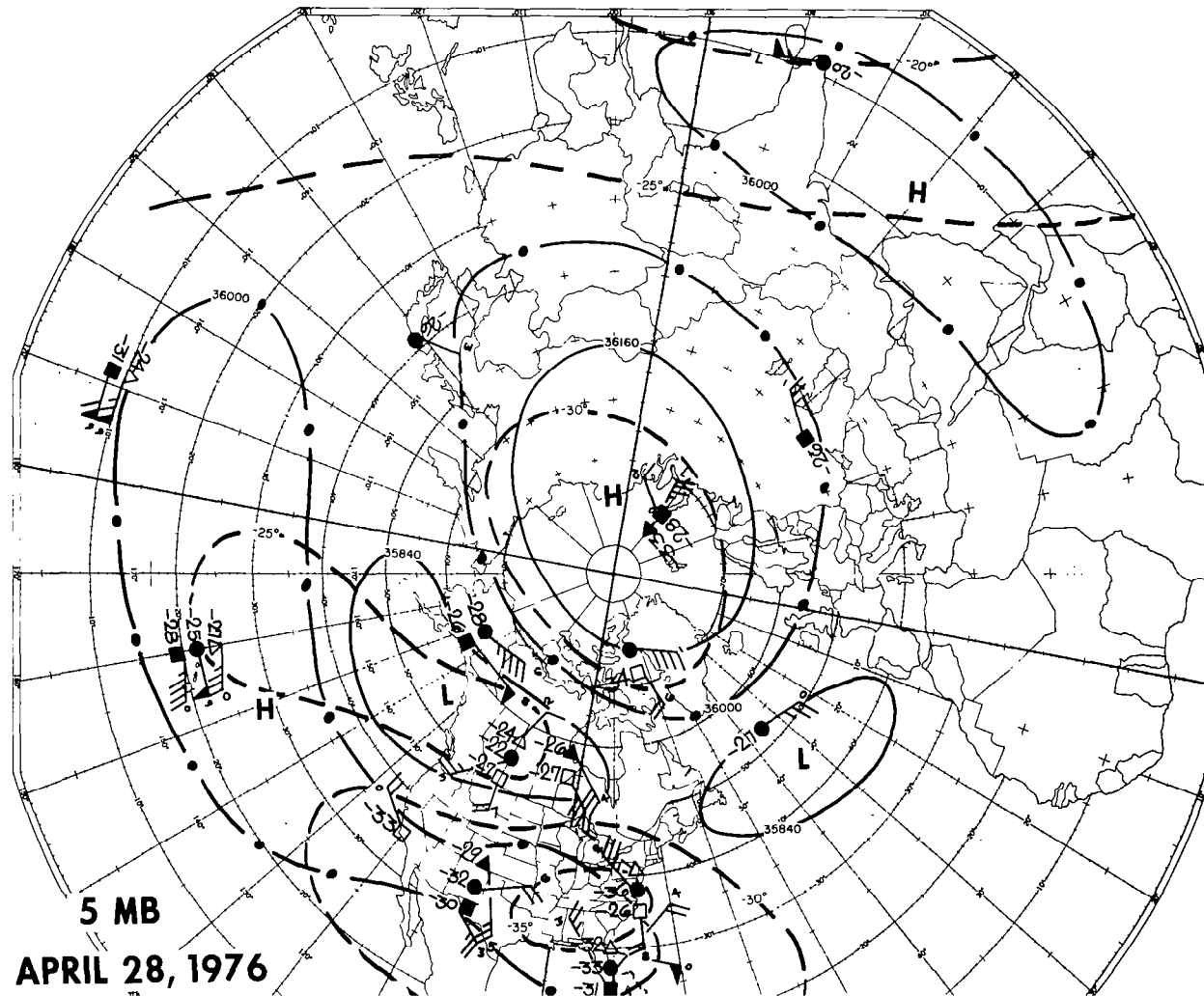








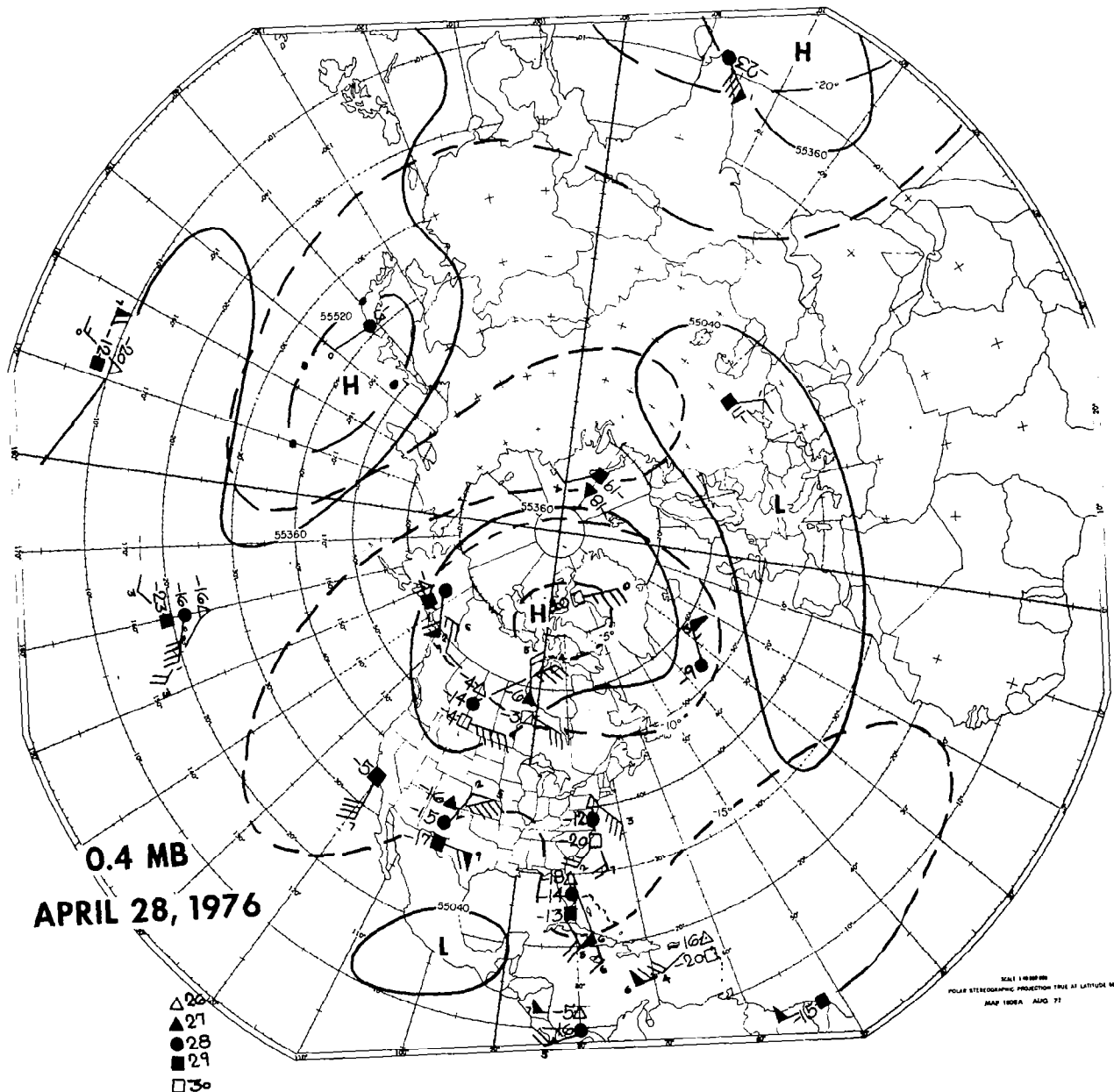


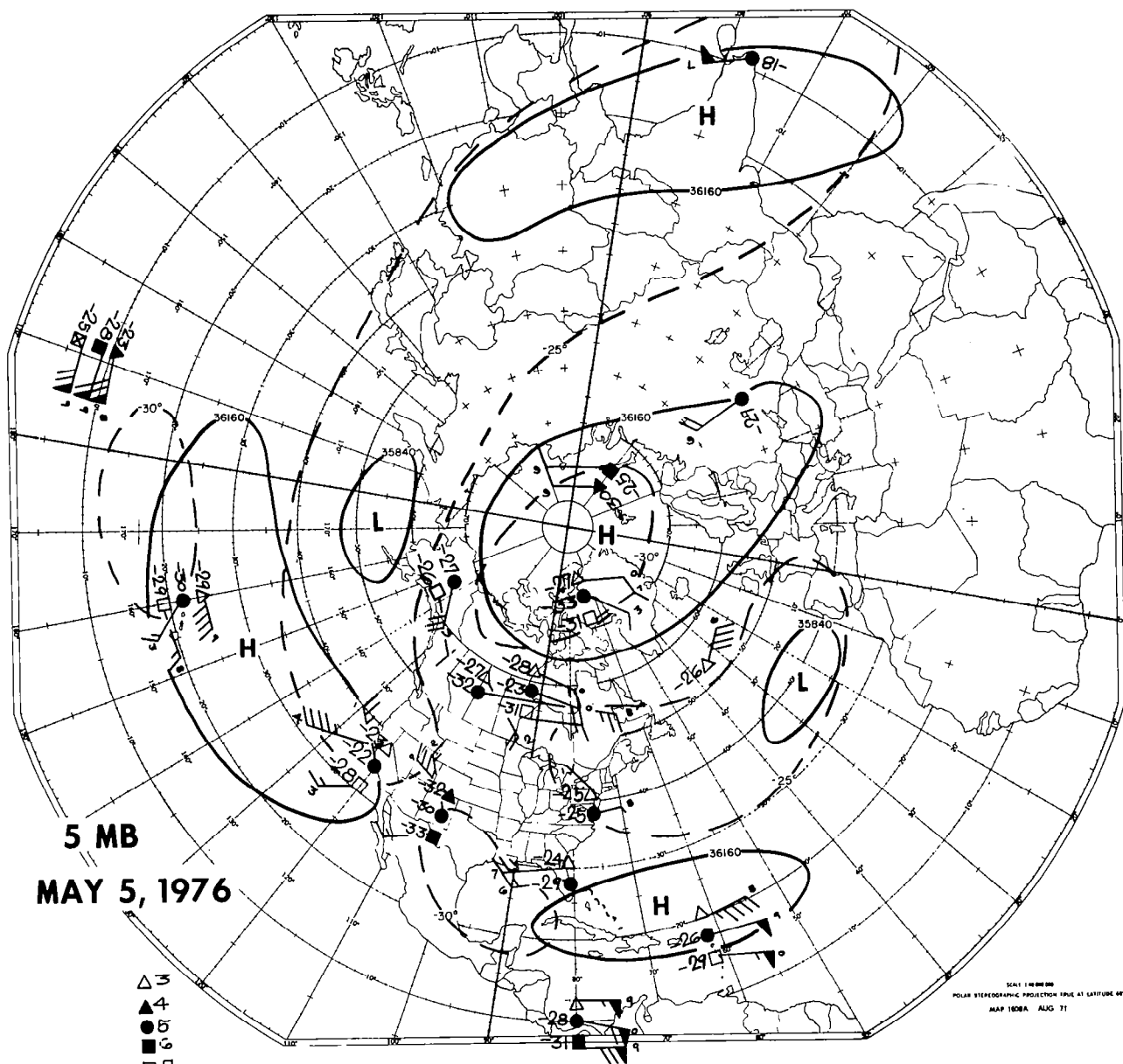


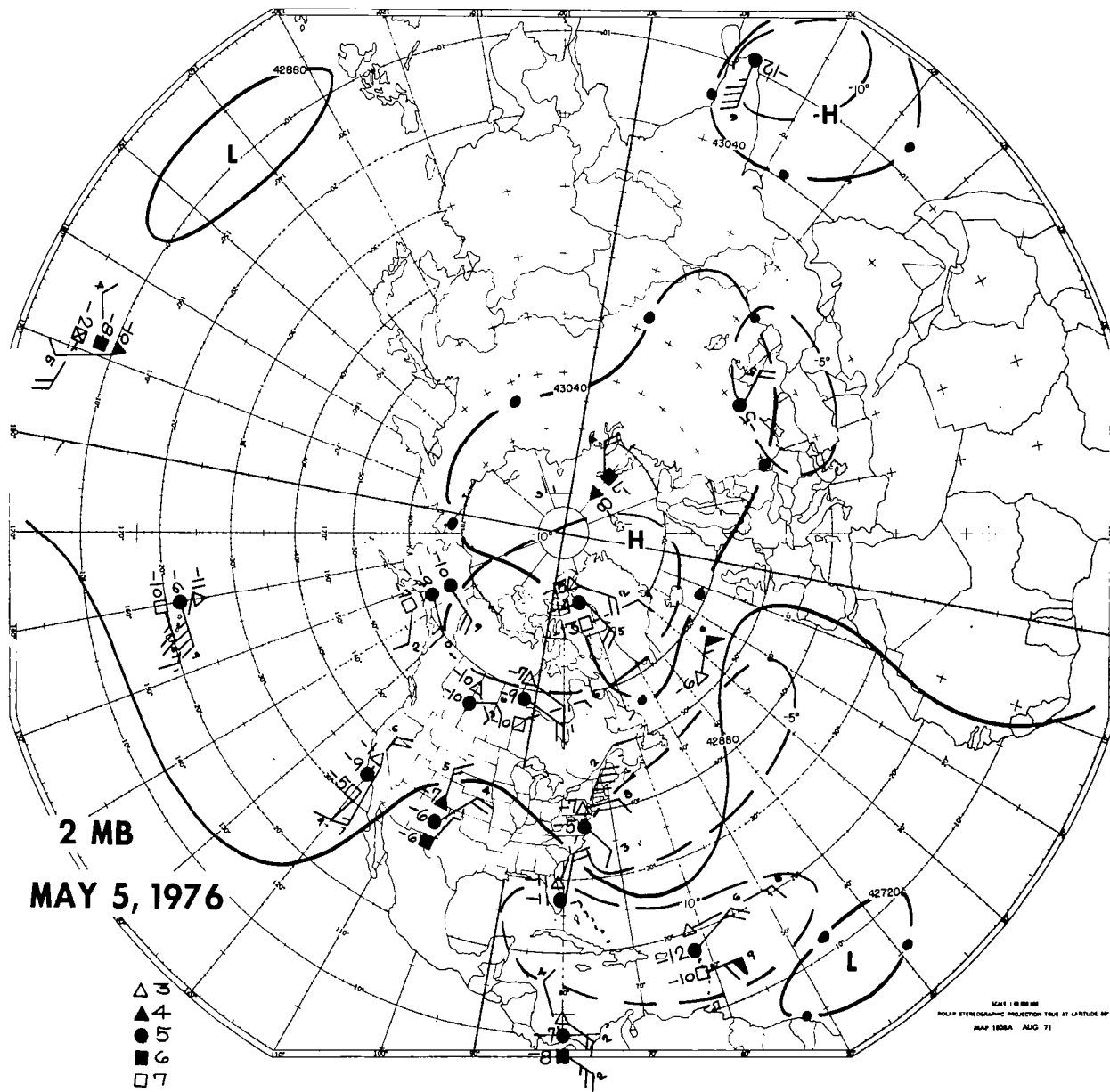
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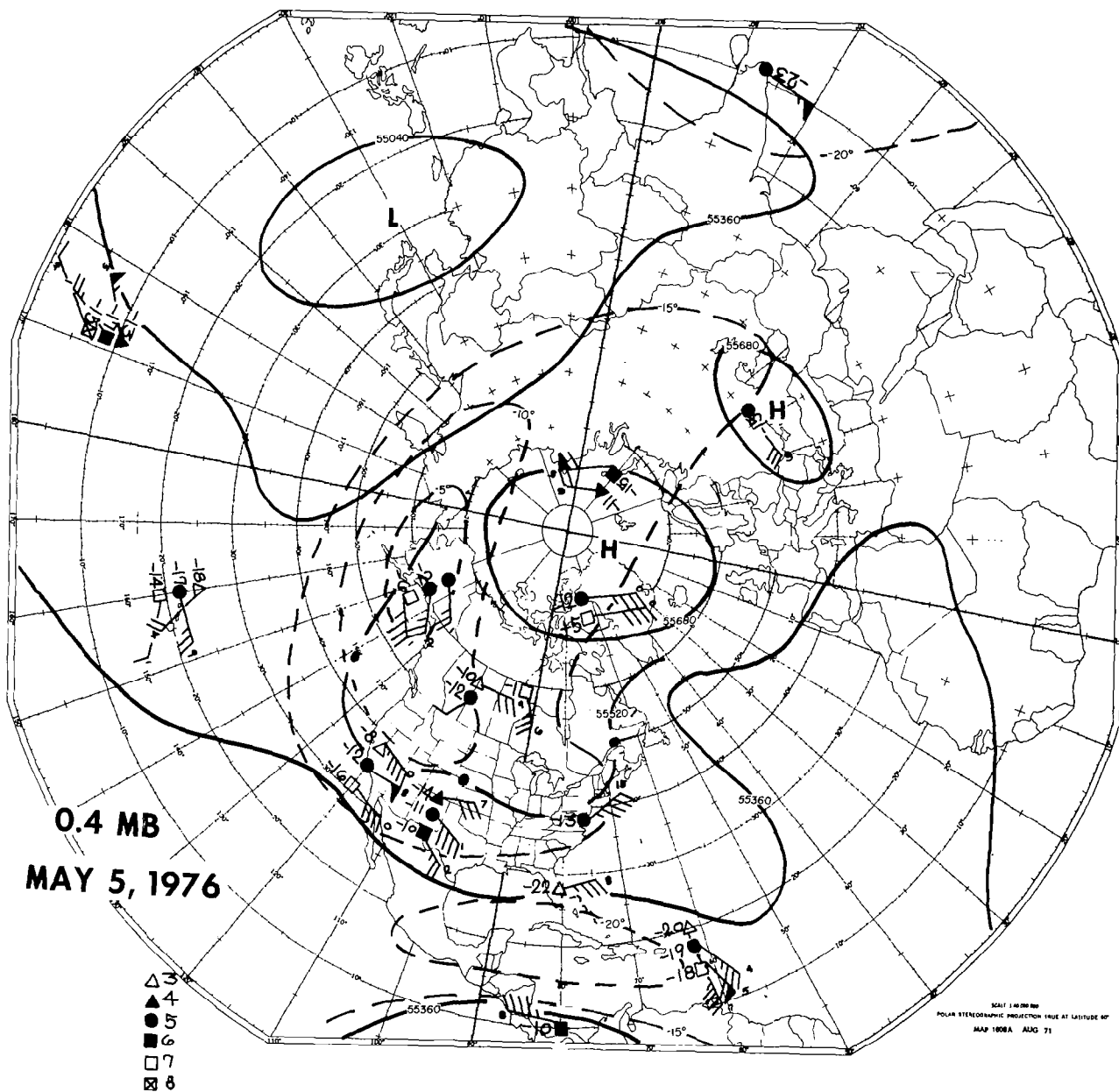
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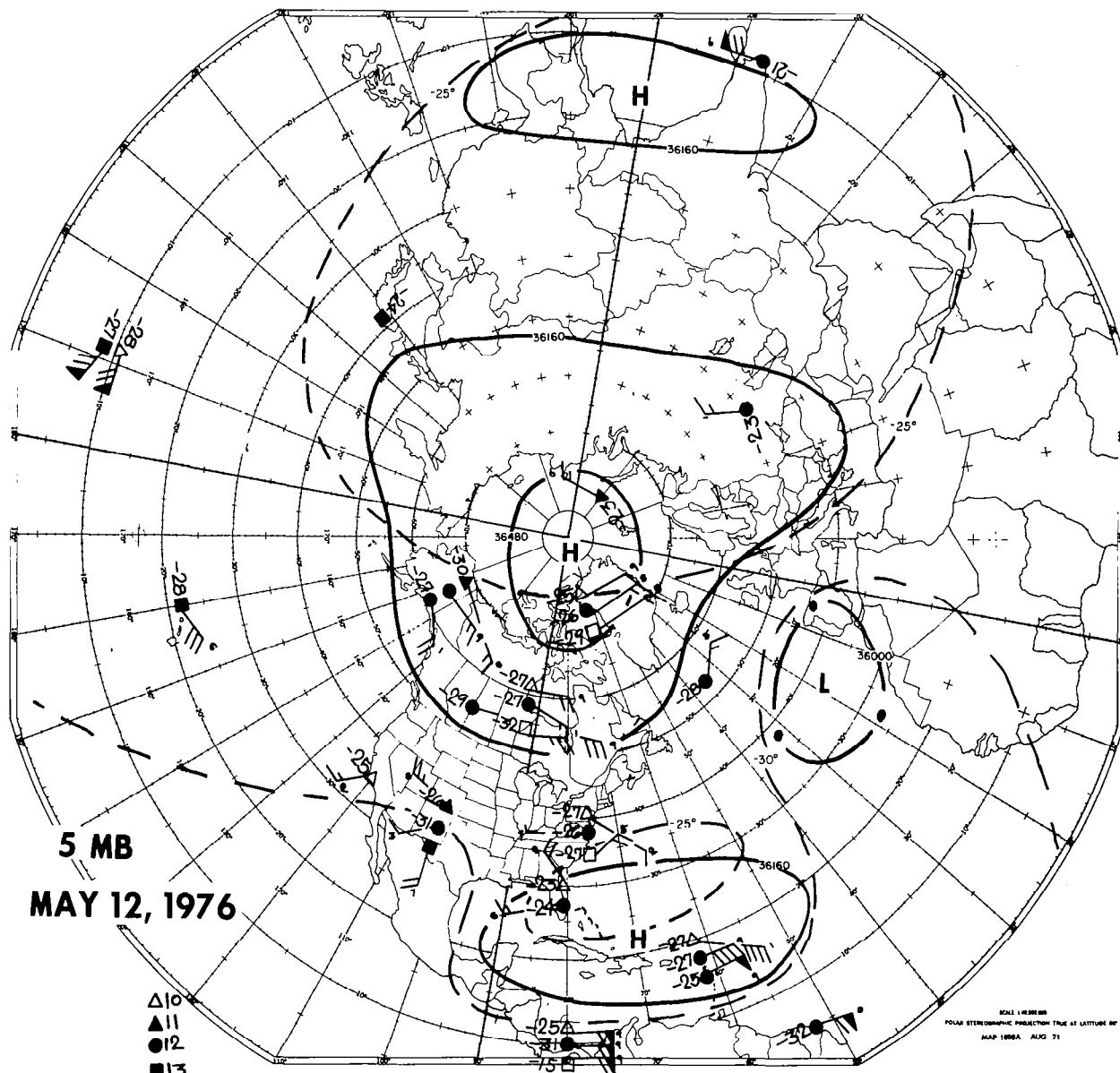




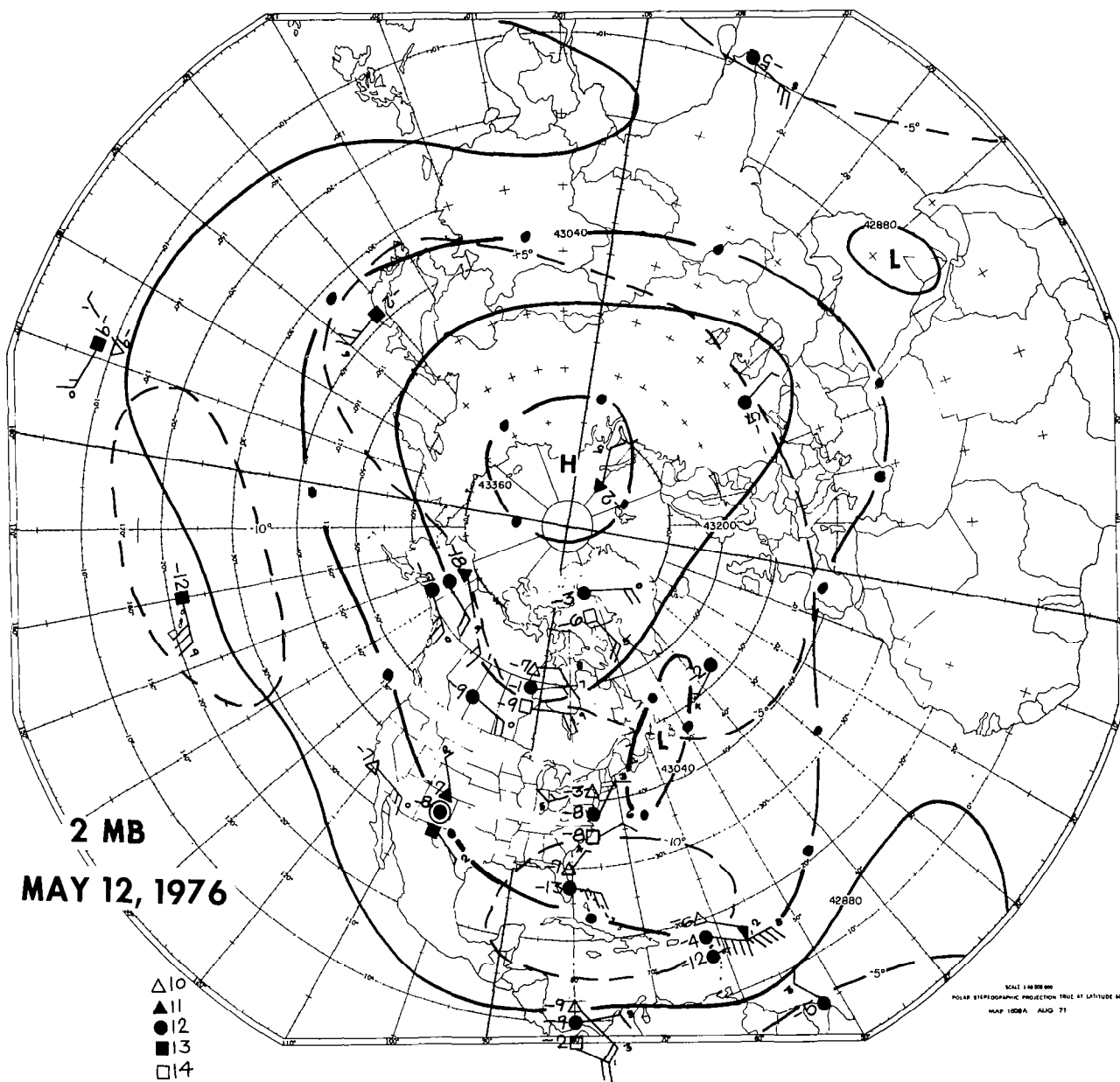


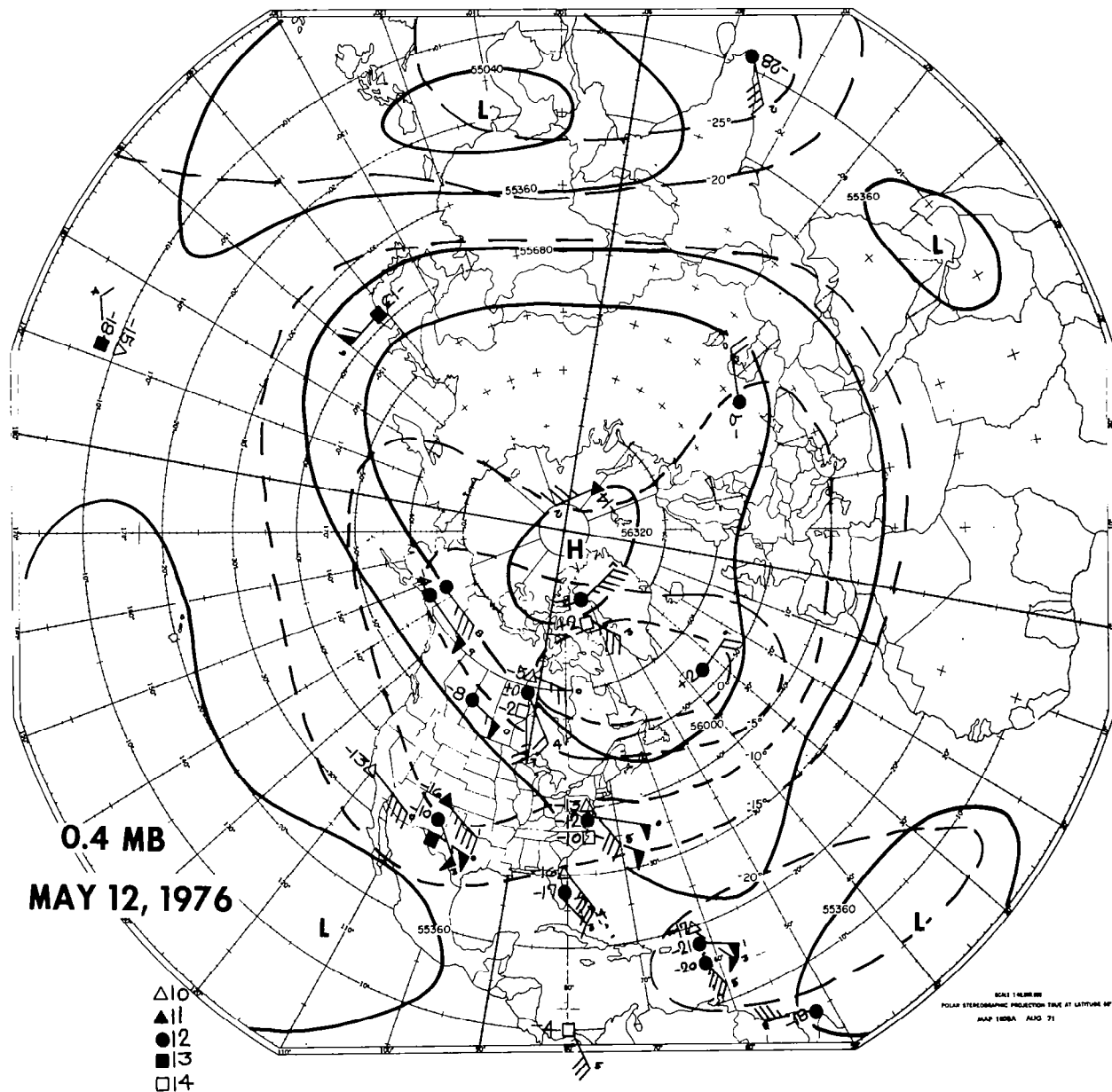


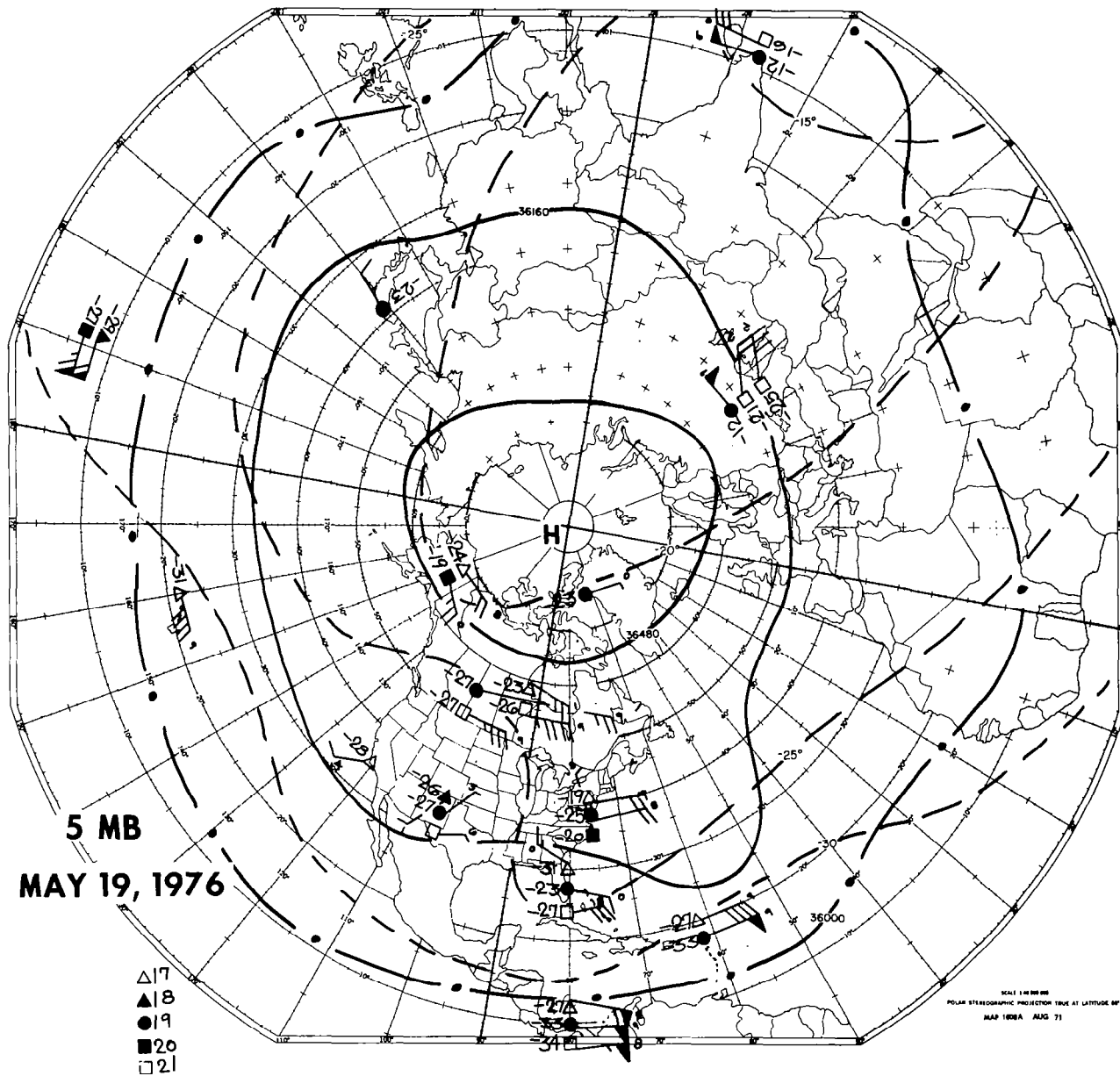


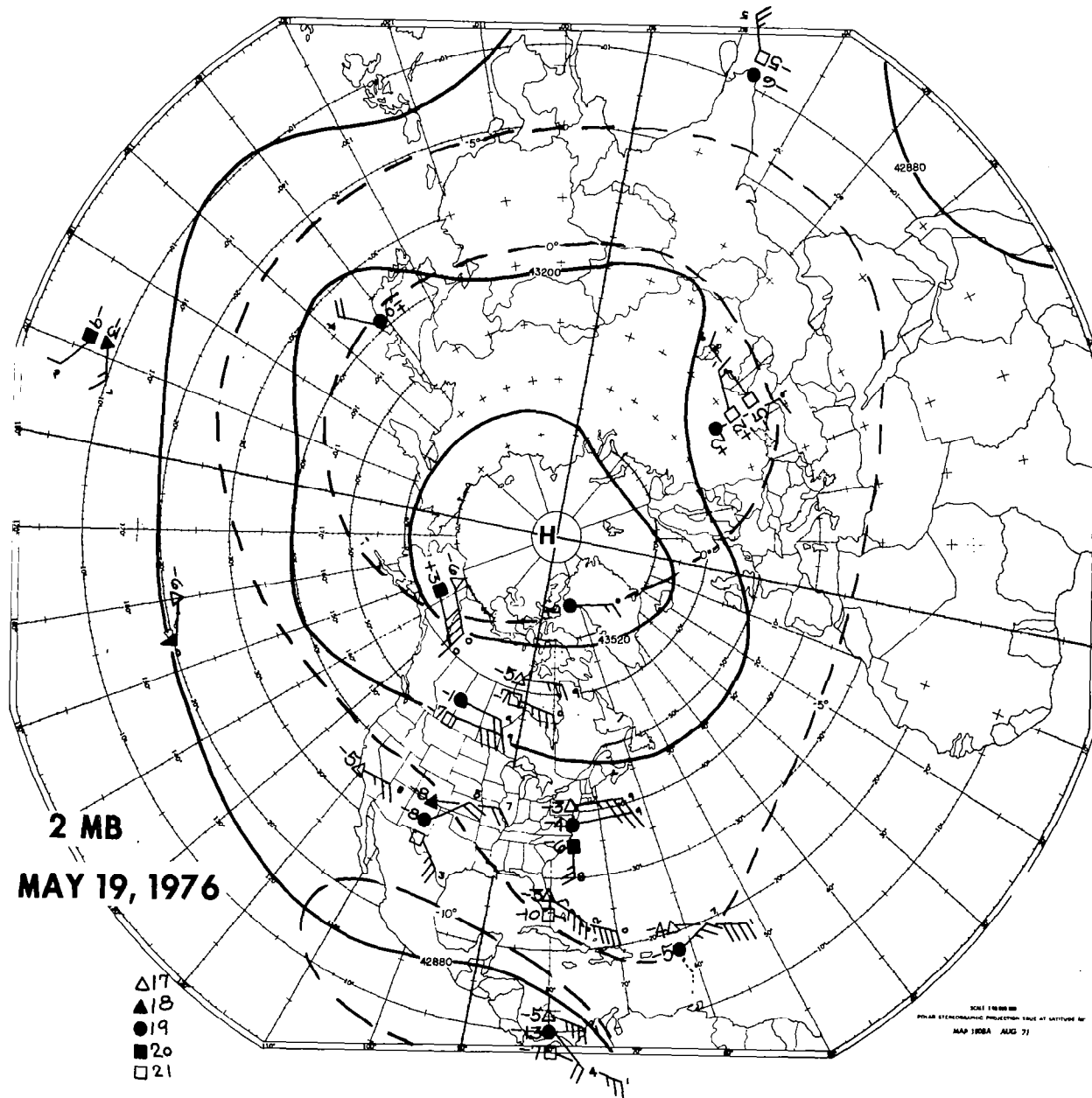


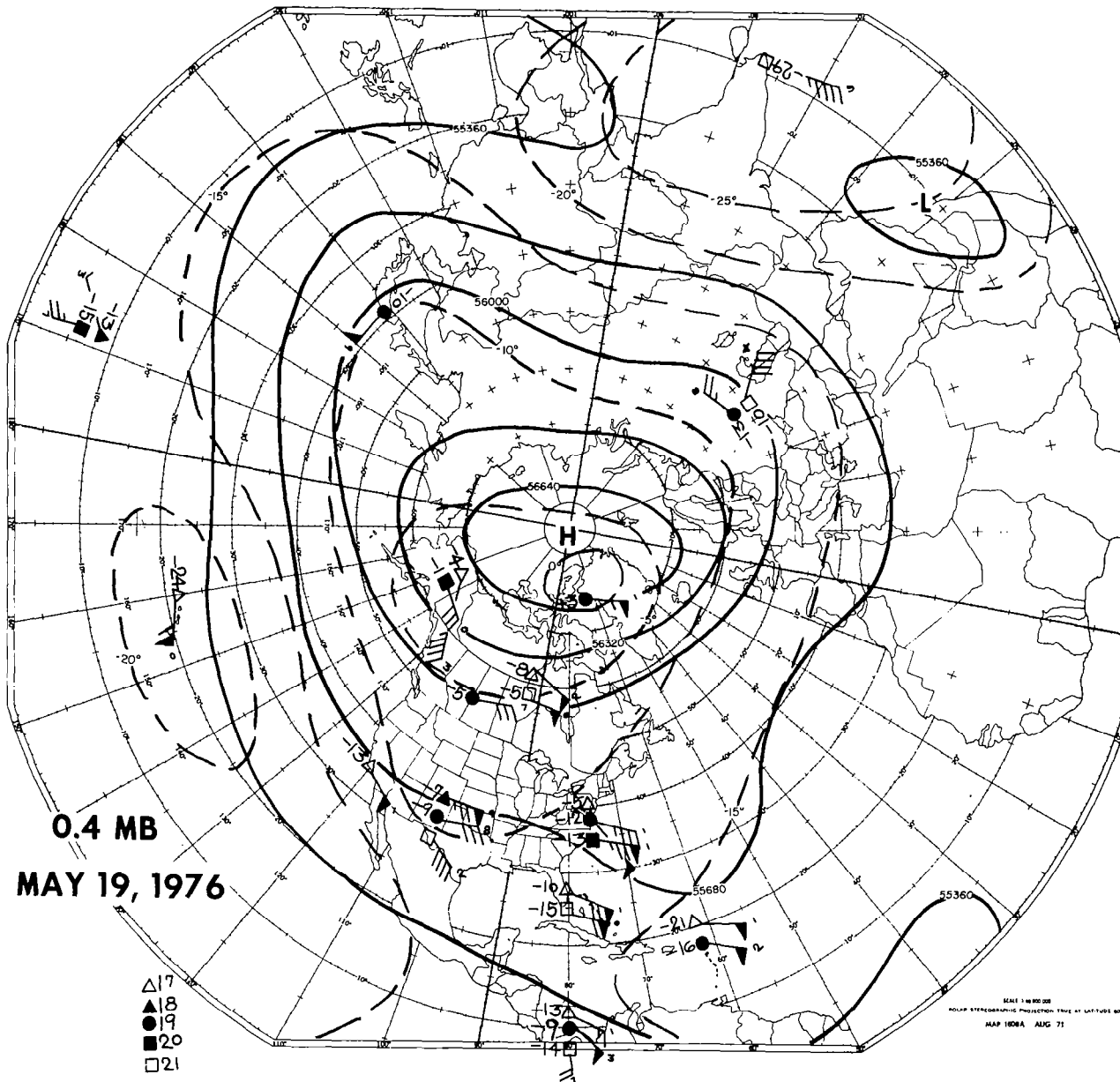


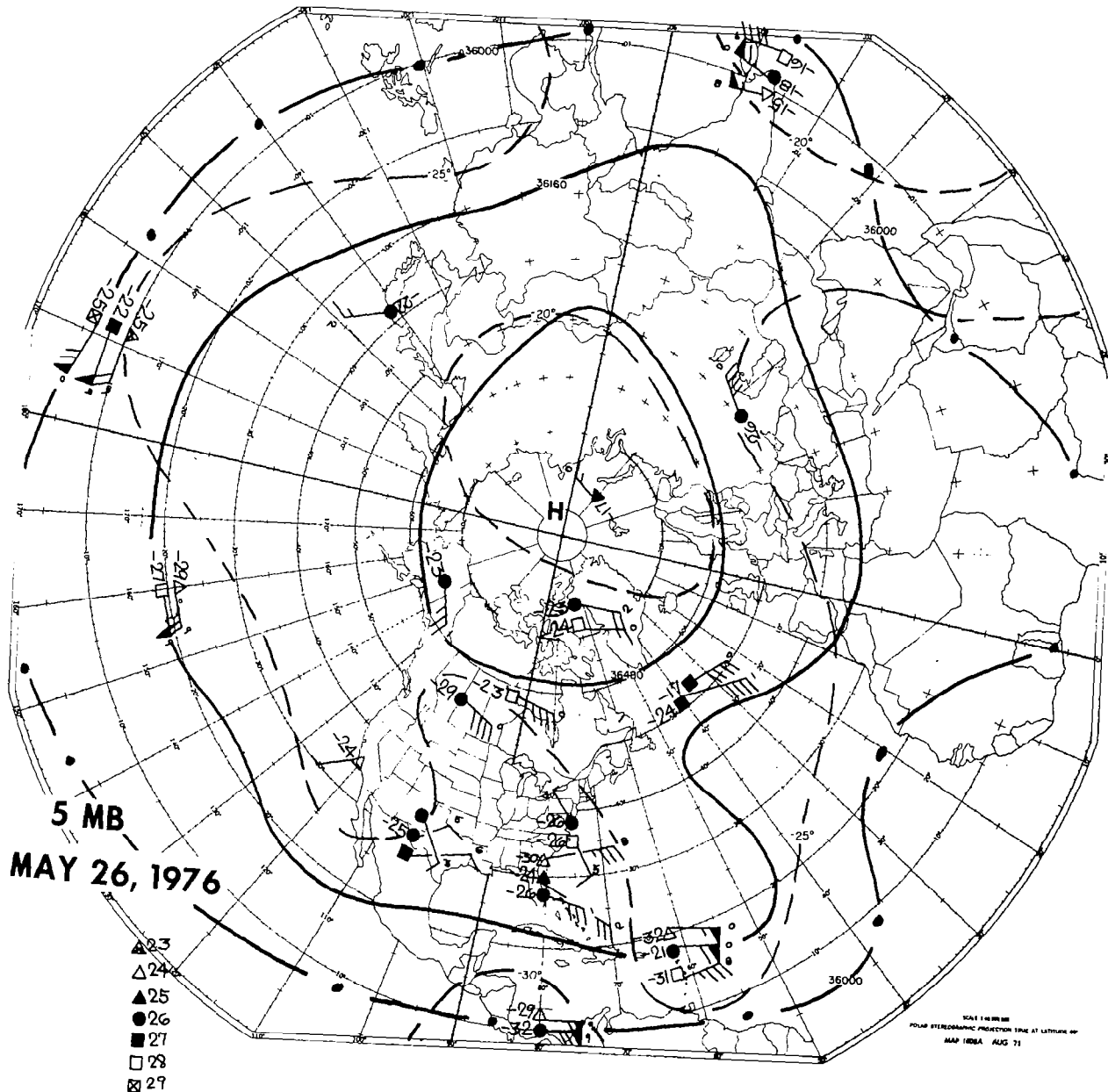






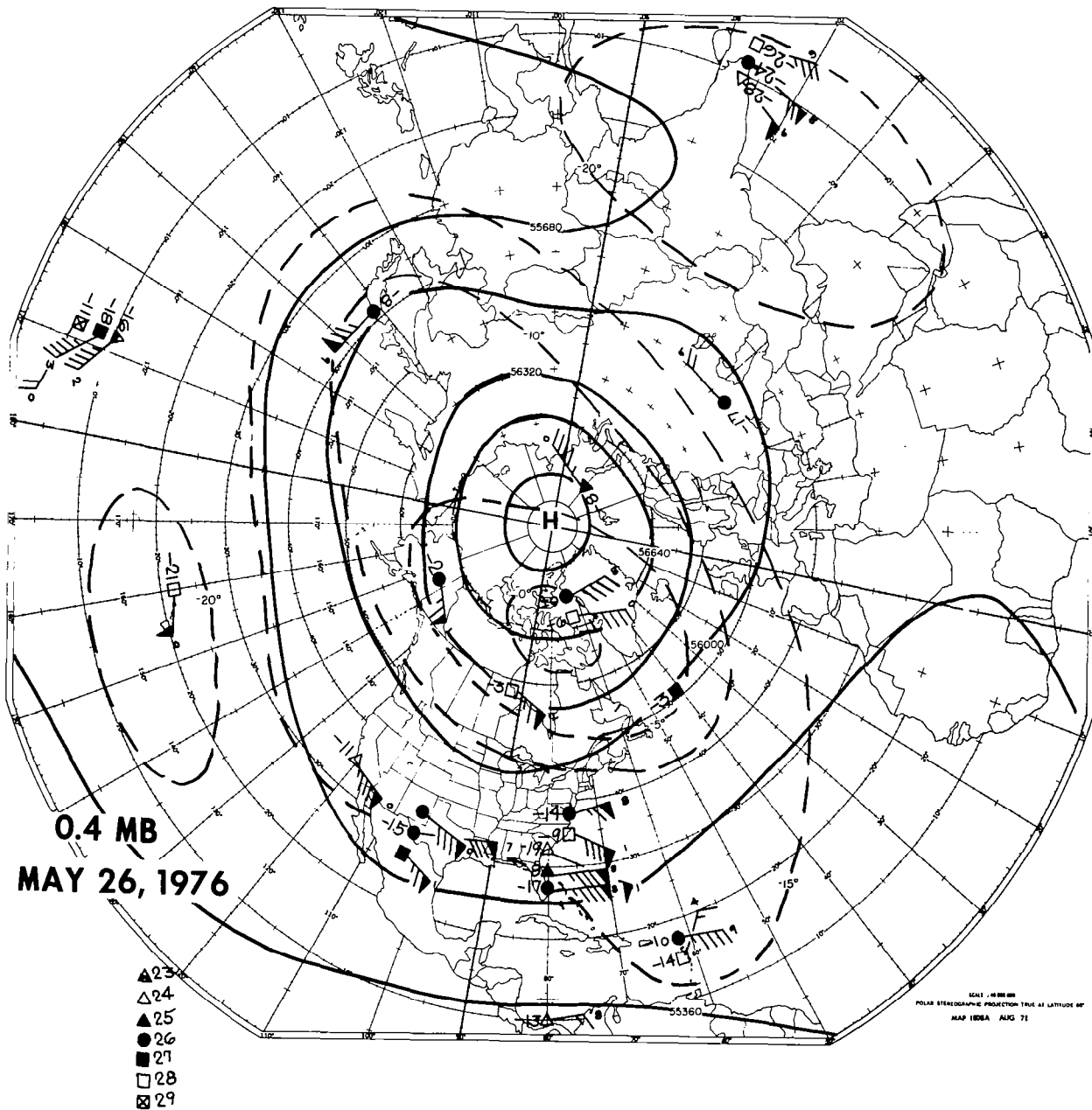




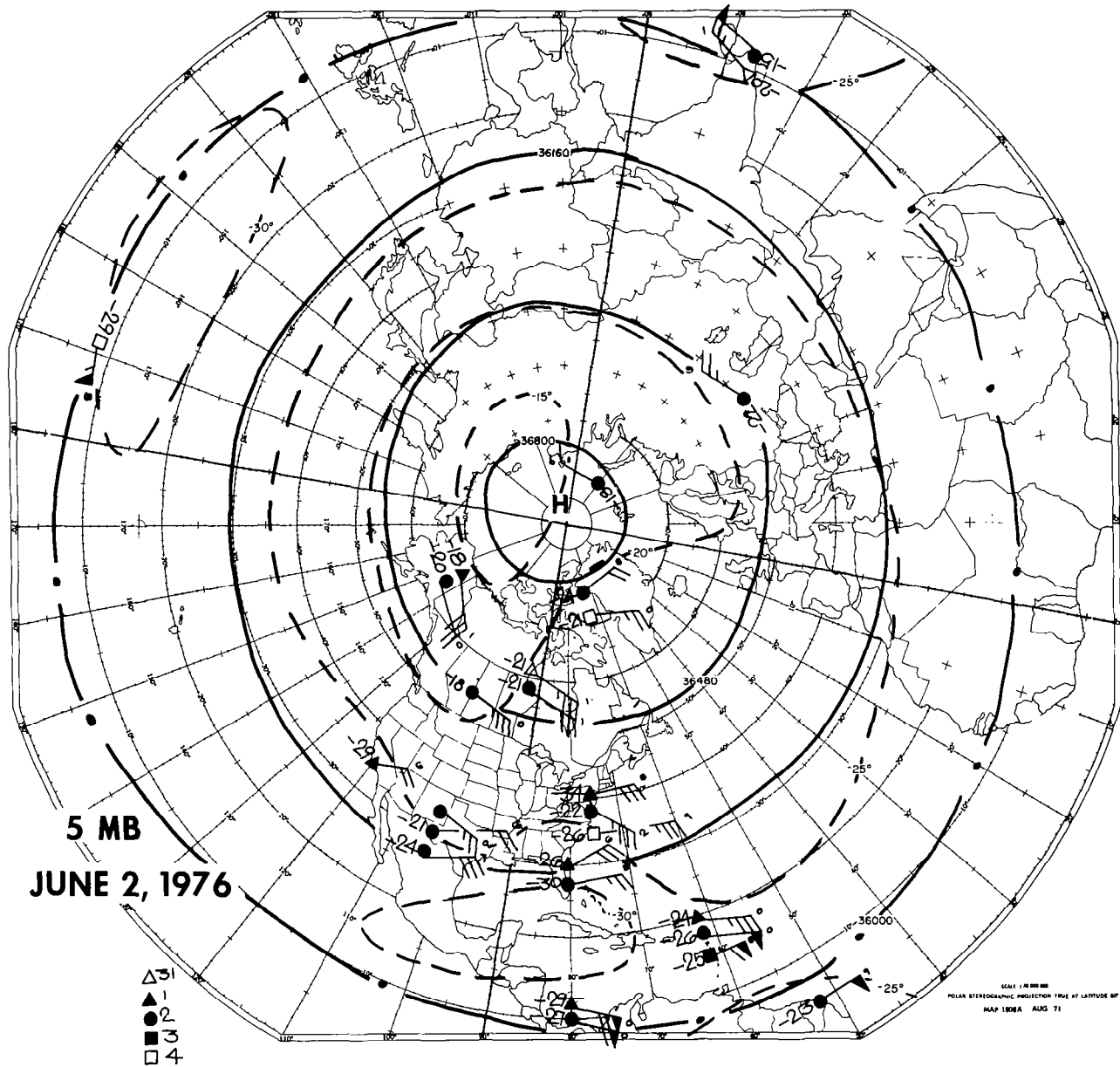


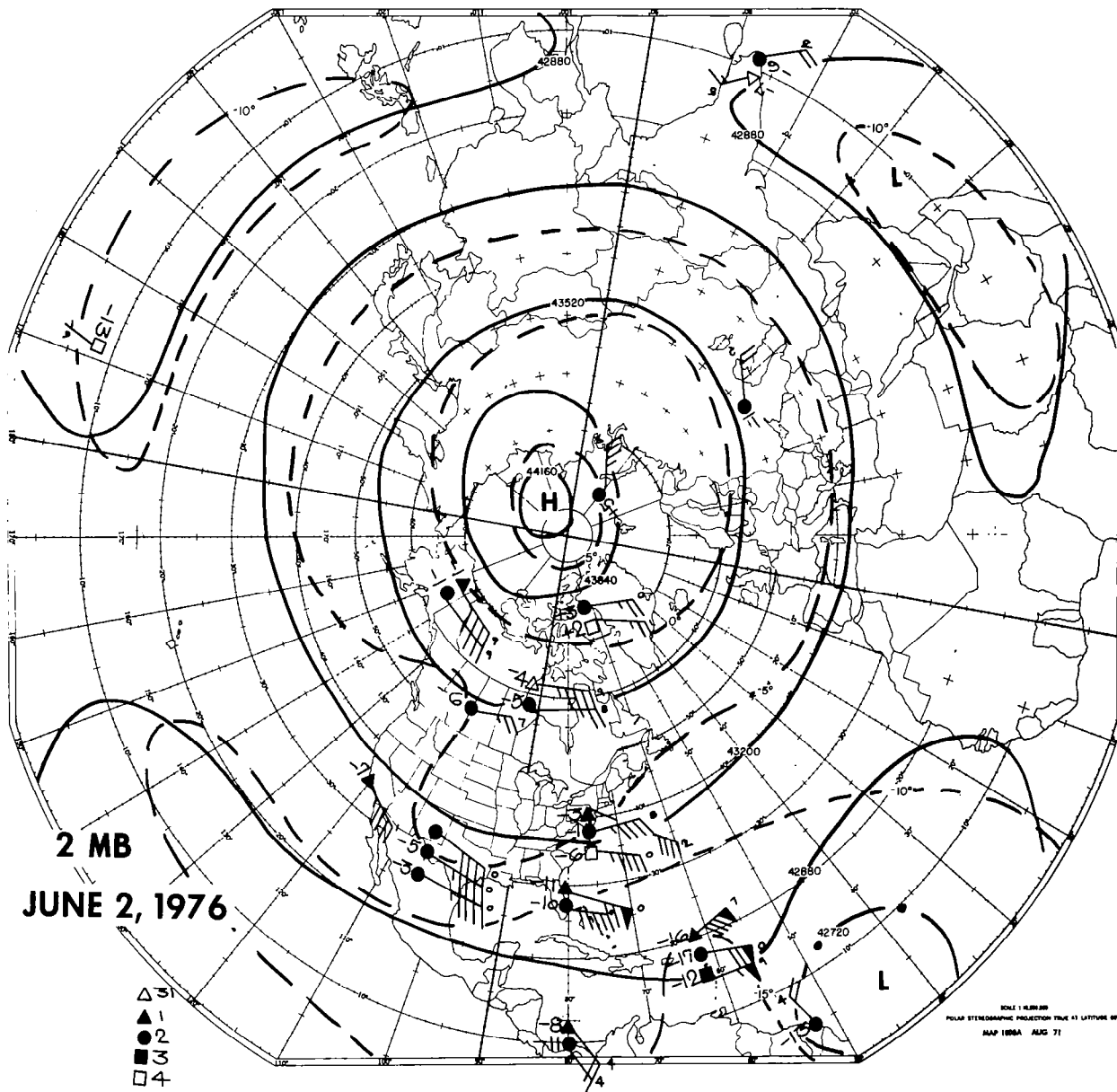
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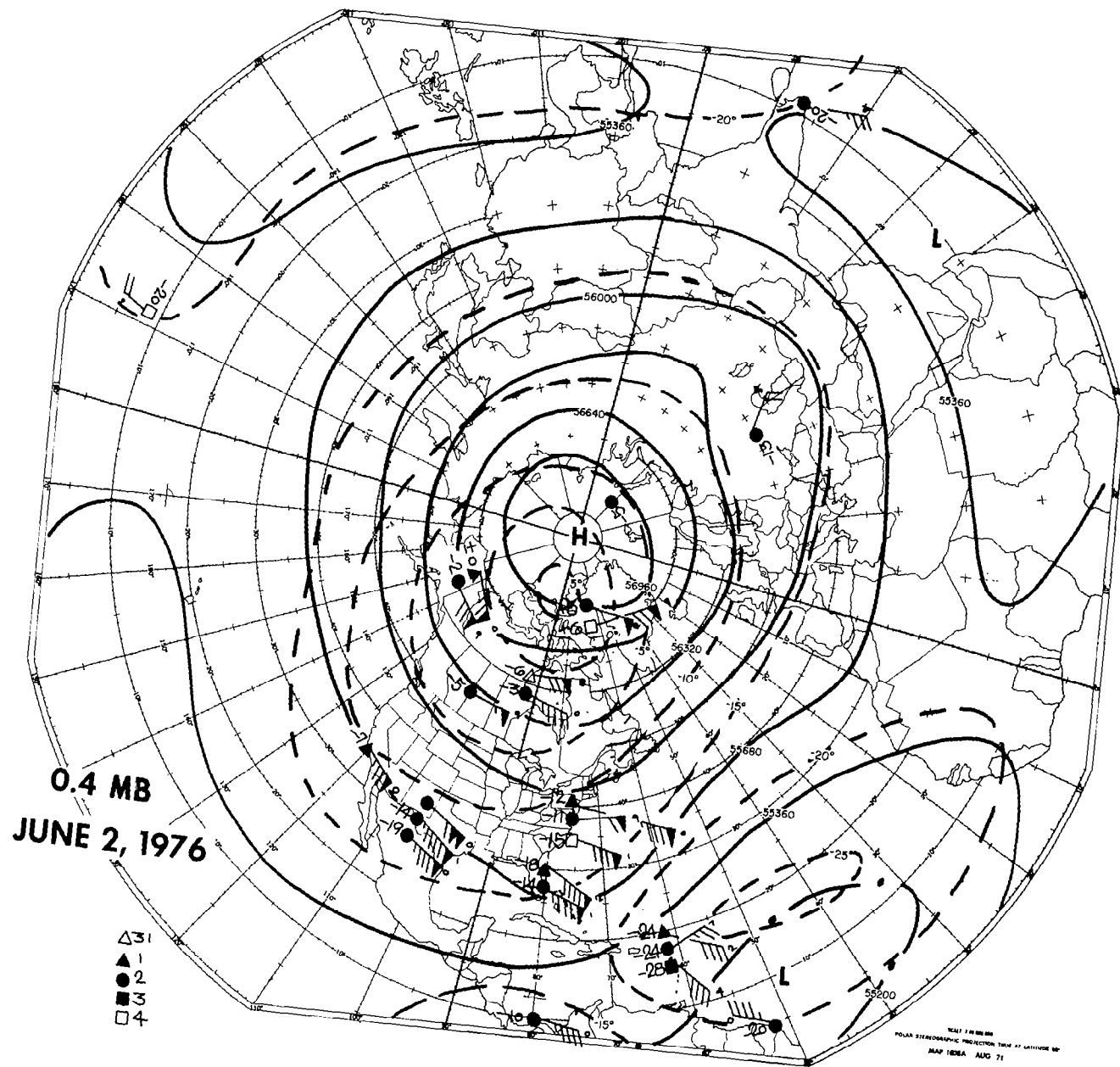
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MAP 1808A AUG 71

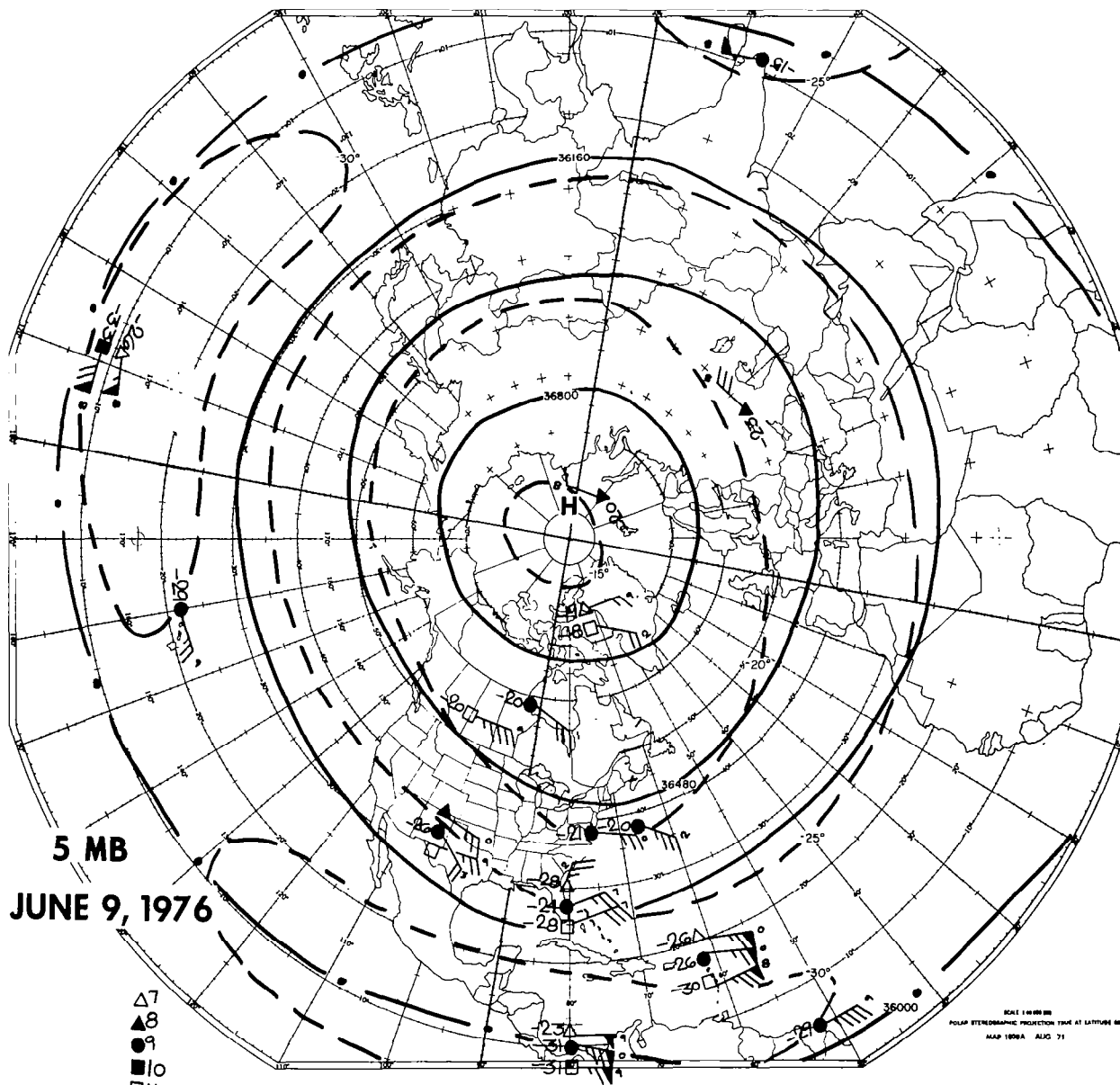


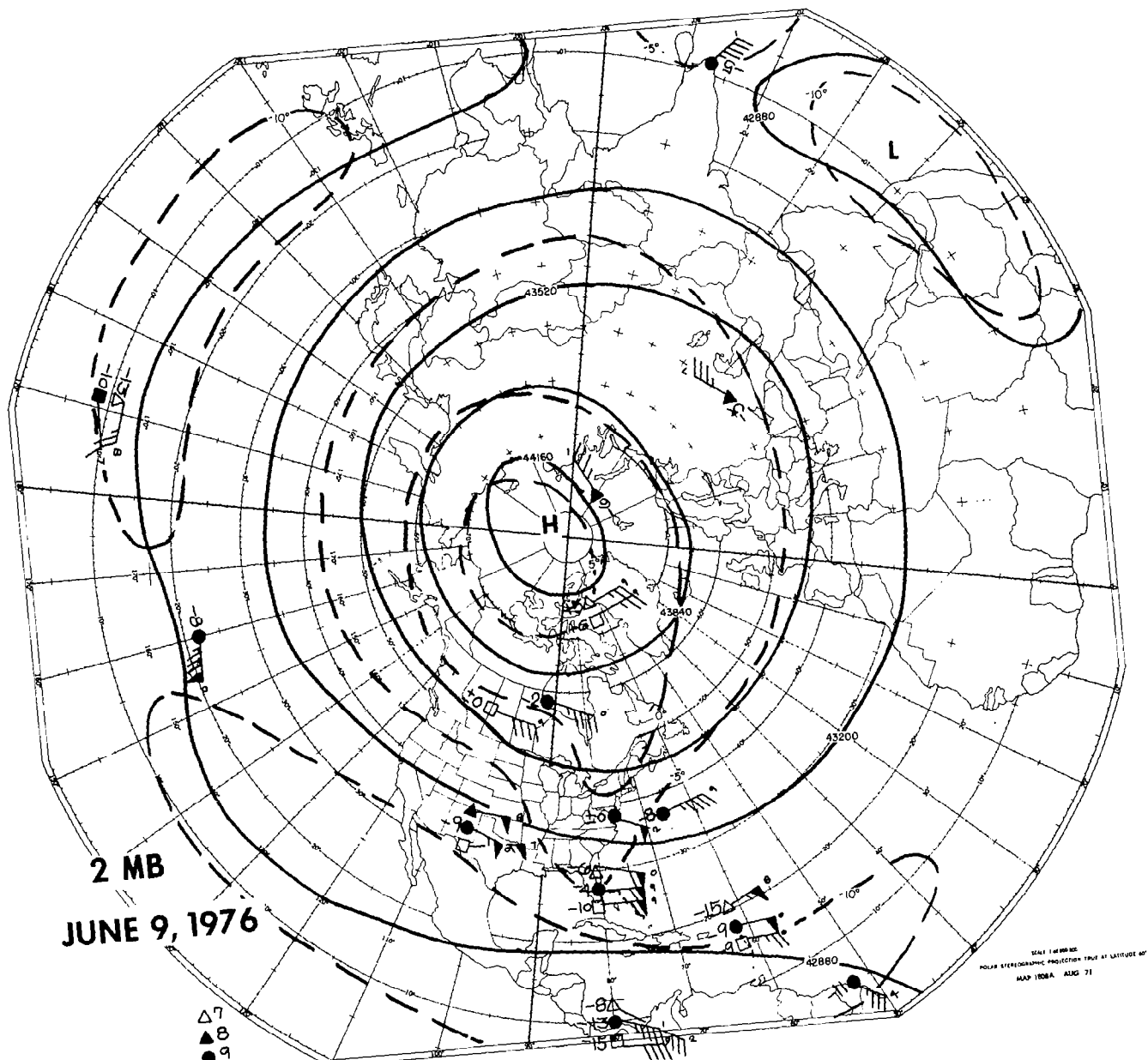


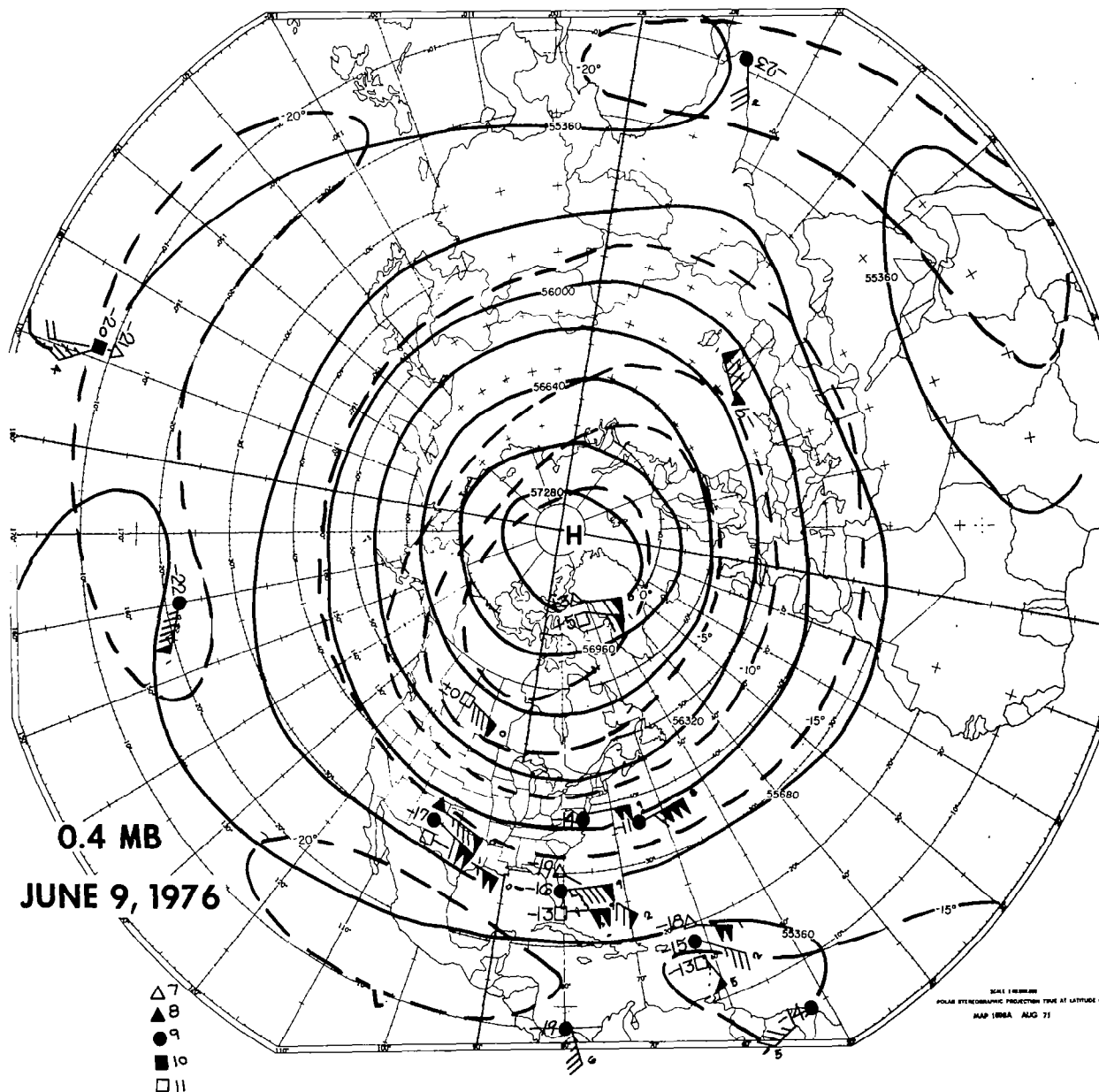


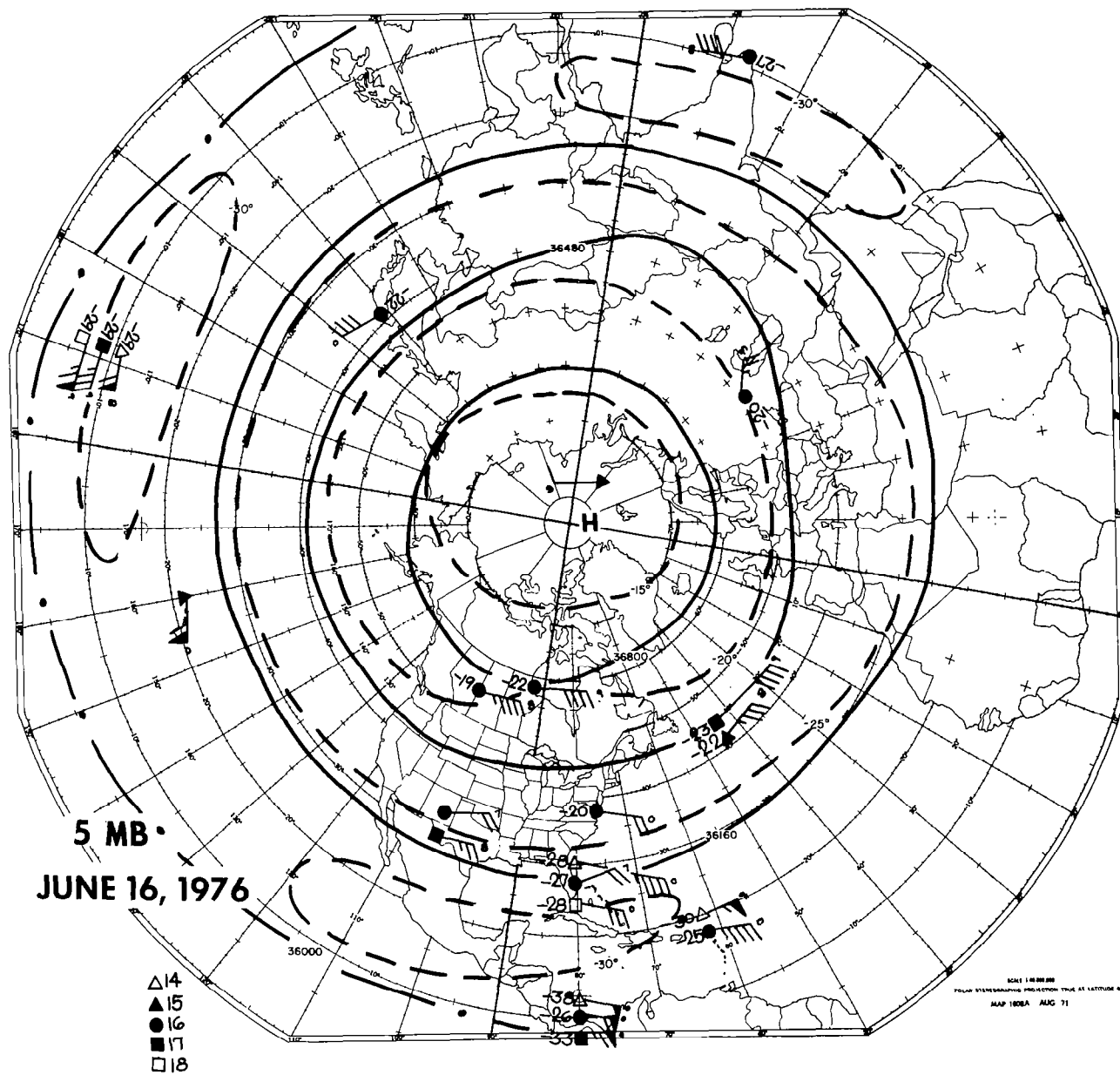


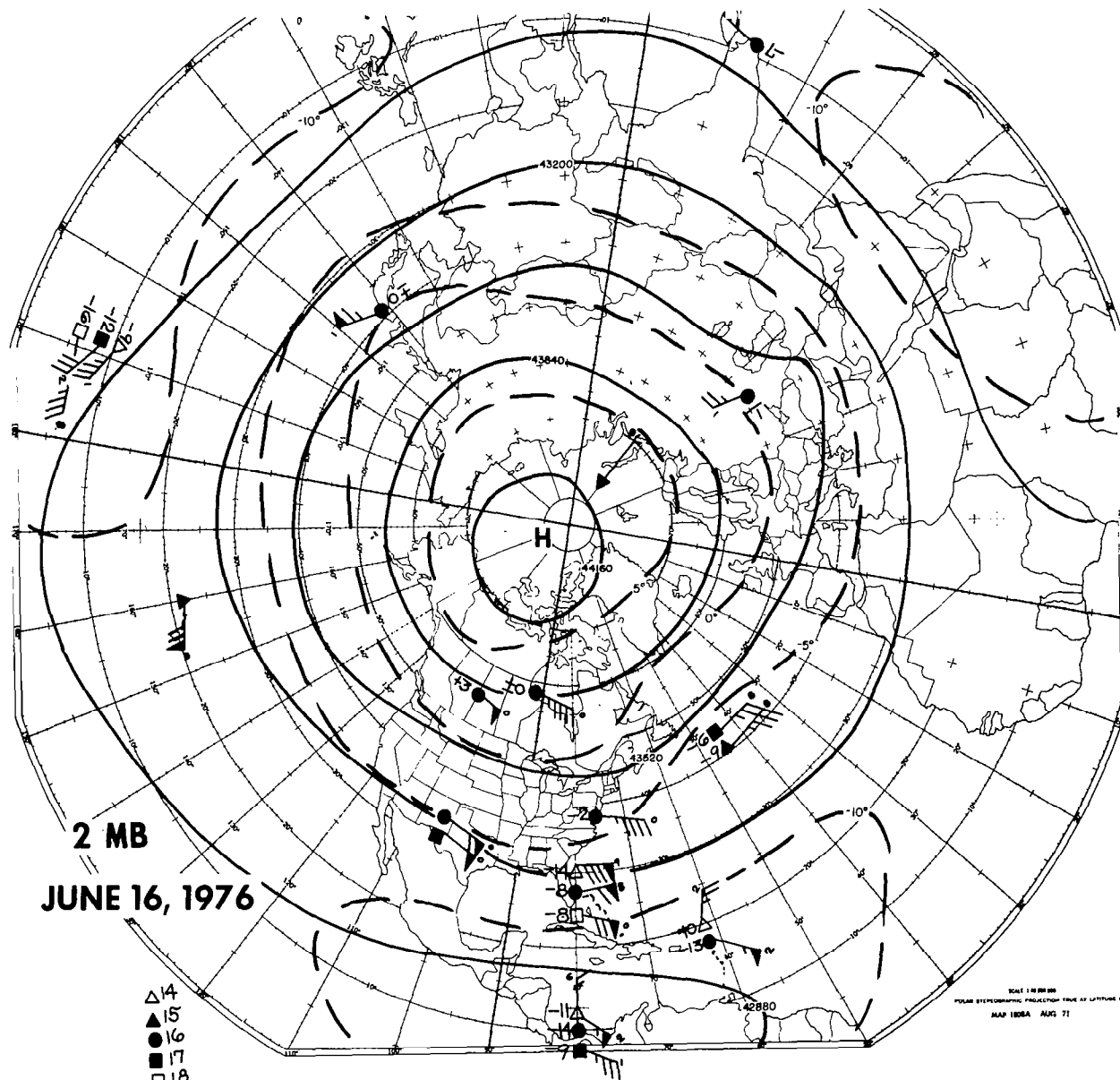




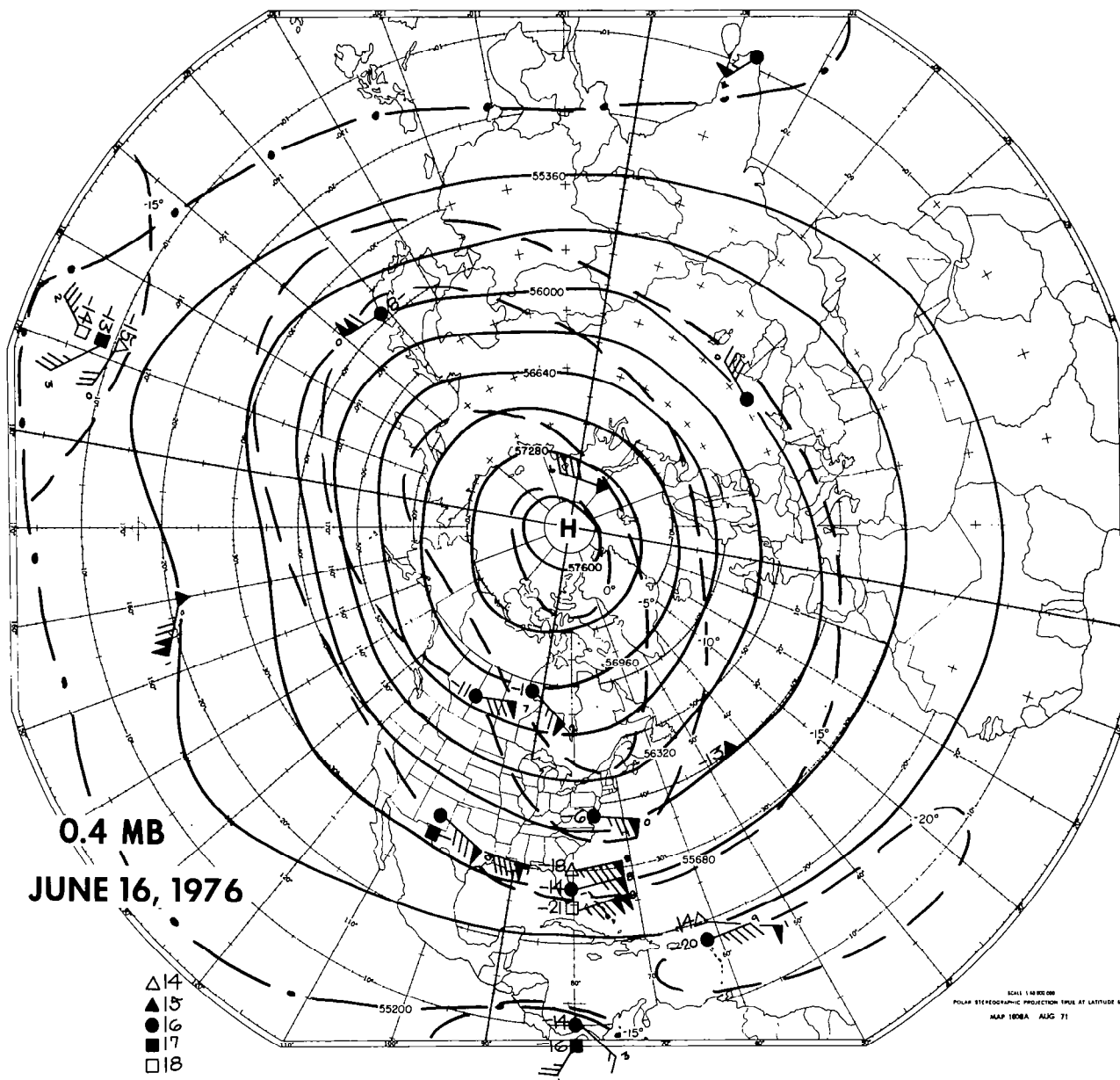


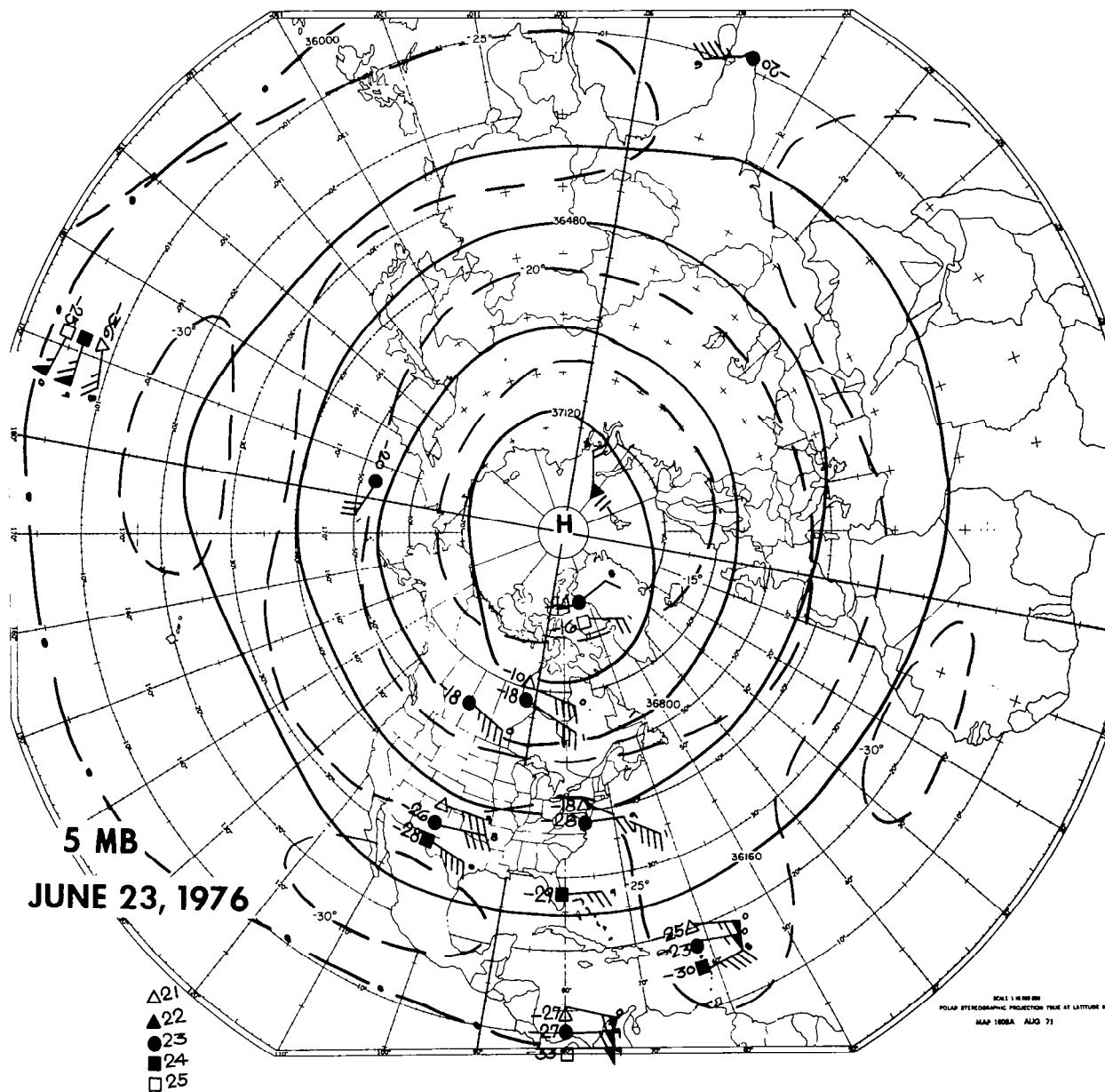


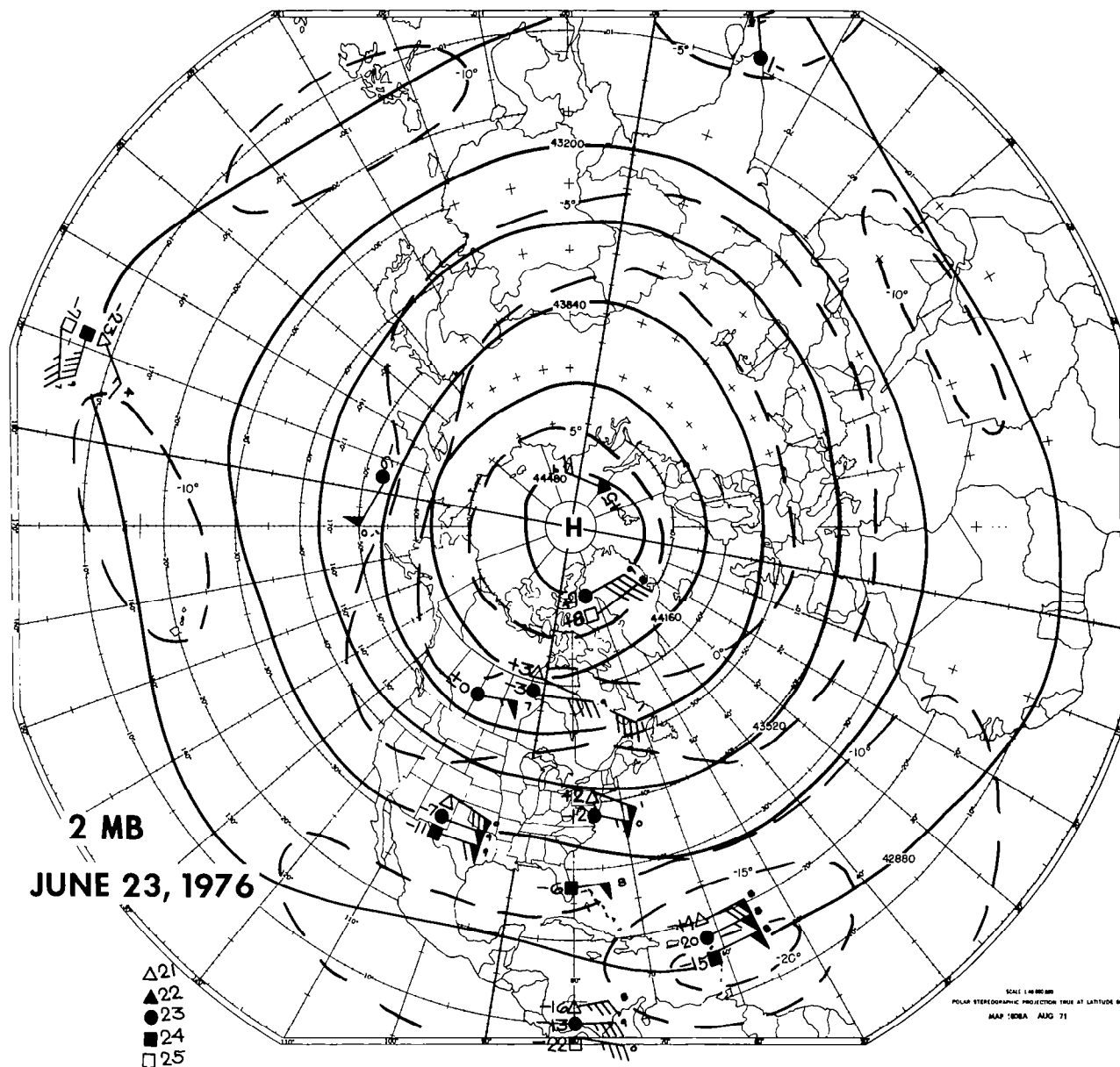


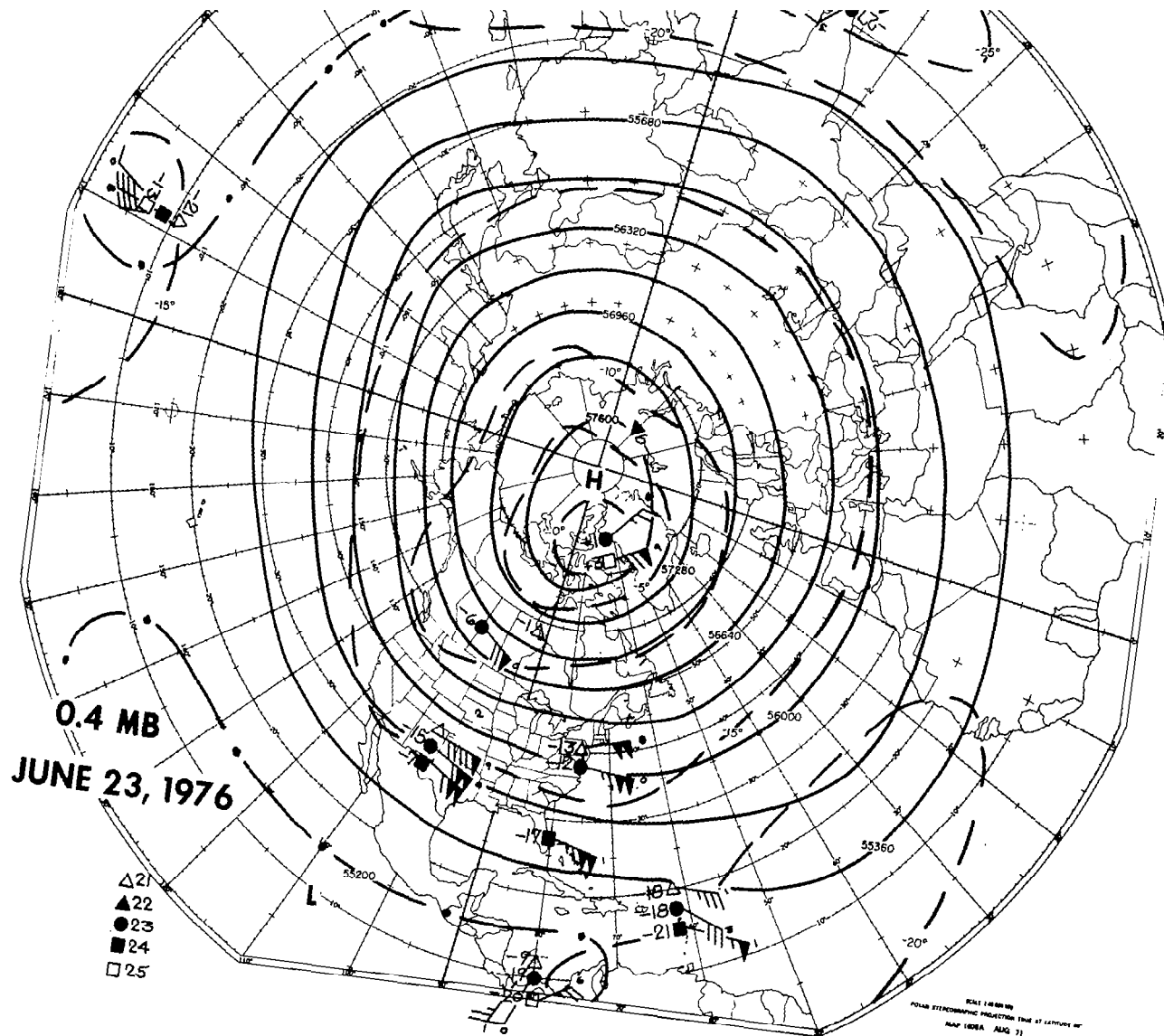


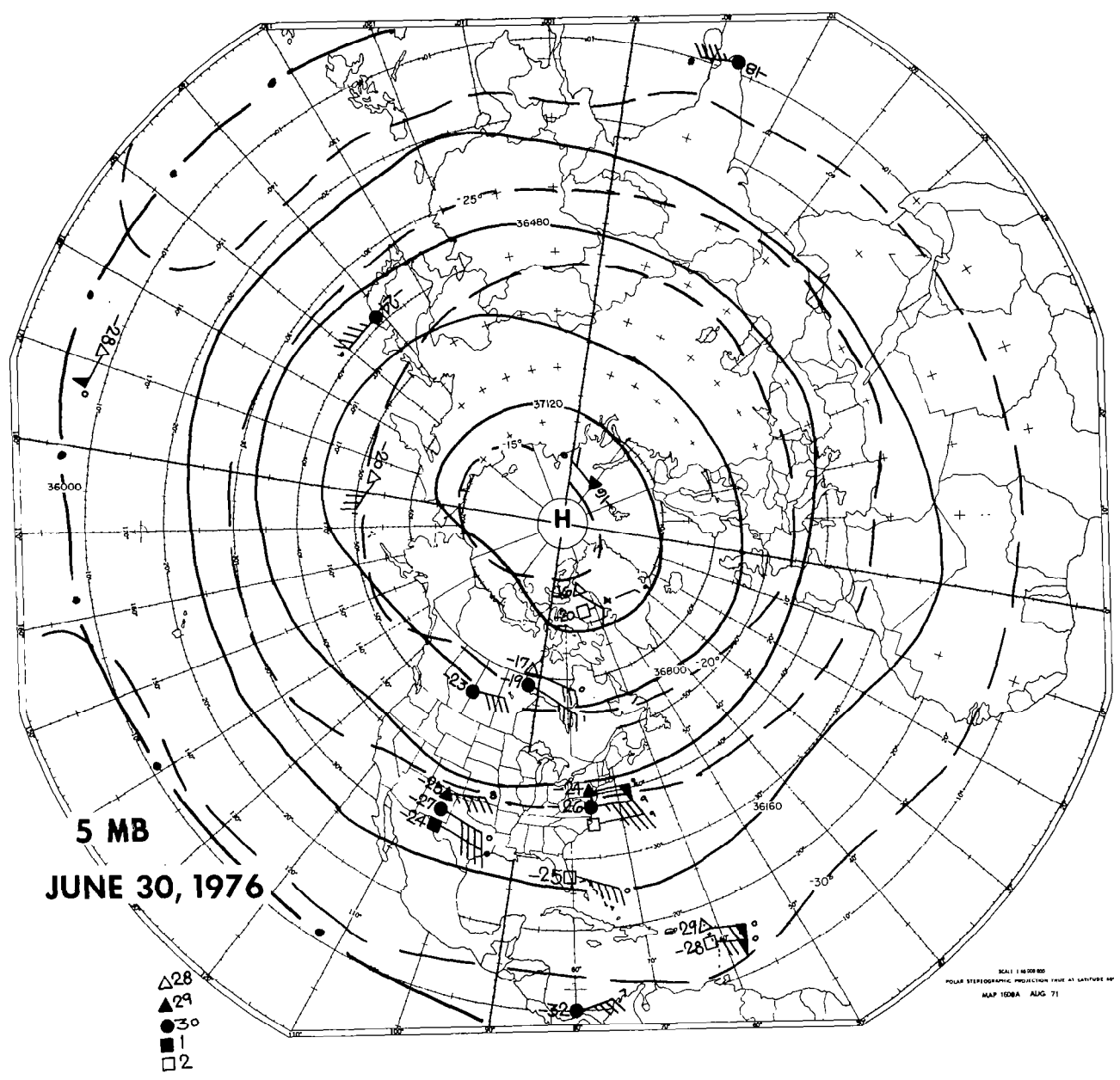


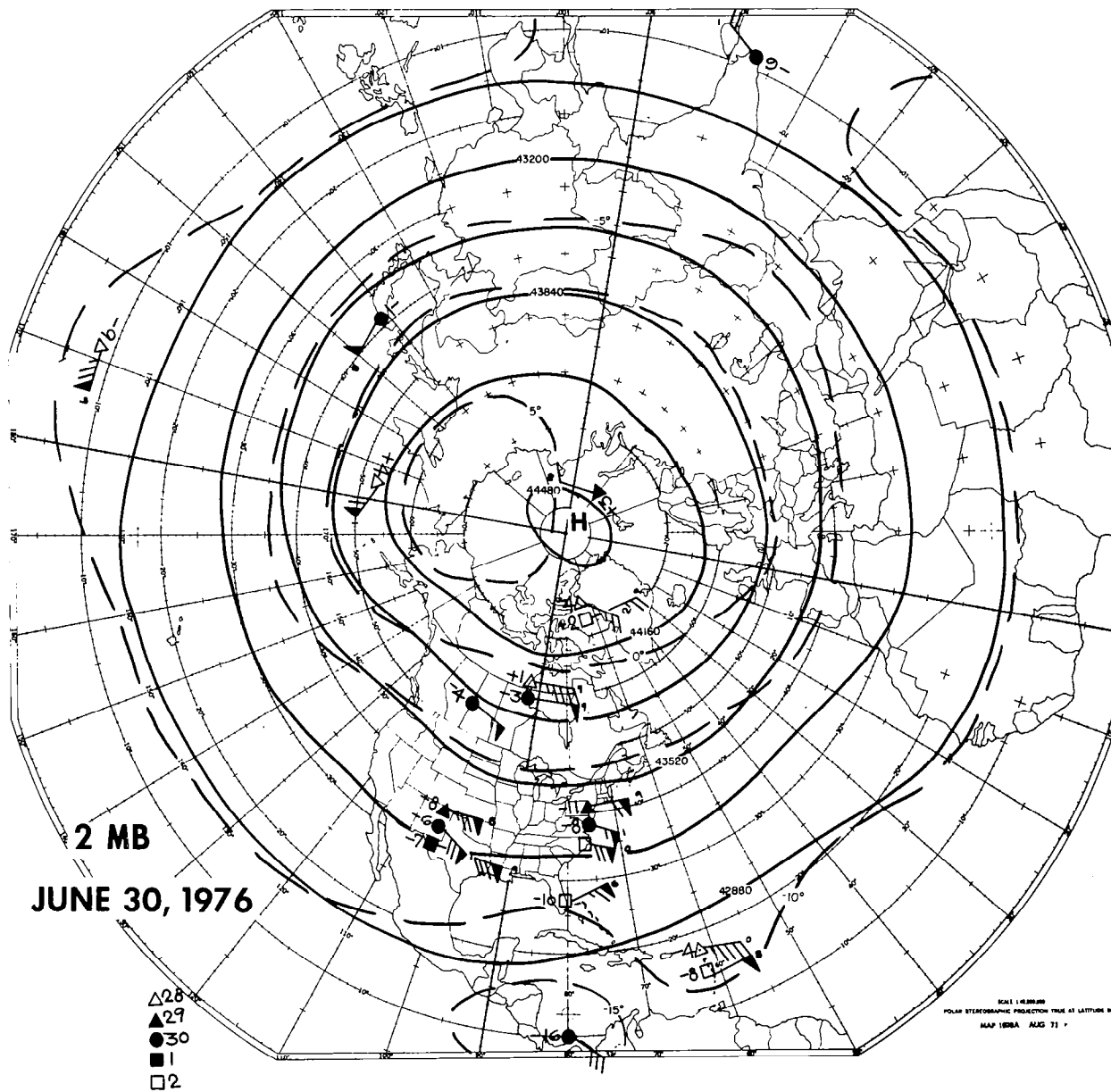


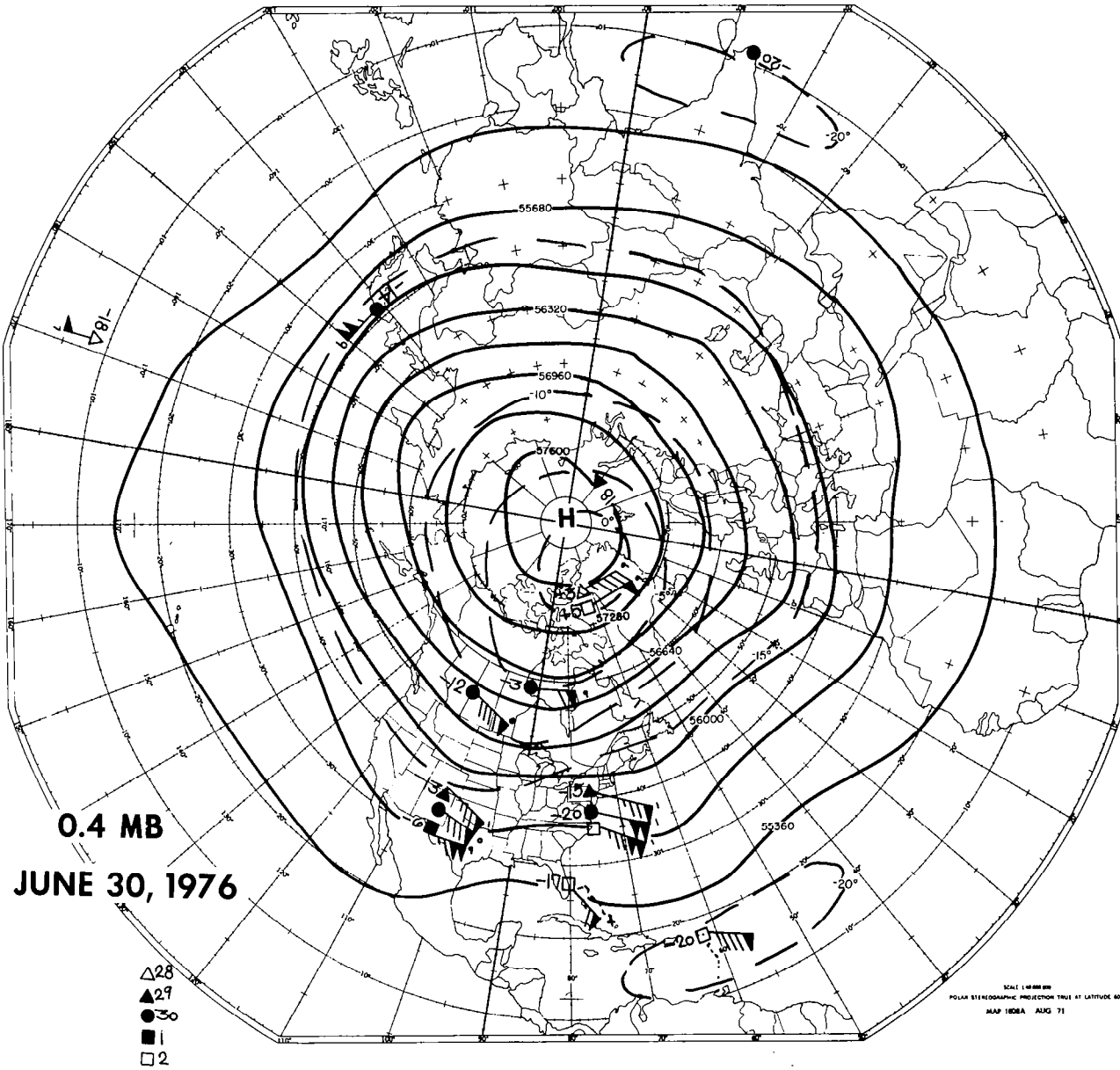












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16. Abstract					
<p>Meteorological rocketsonde and satellite radiance data have been employed for analyses of a continuing series of high-altitude constant-pressure charts. The methods of processing, the various types of data utilized and the analysis procedure are described.</p> <p>Broad-scale analyses of temperature and geopotential height for the Northern Hemisphere 5-, 2-, and 0.4-mb surfaces are presented for each week of the period July 1974 through June 1976.</p> <p>Brief discussions of the variations of the temperature and height fields throughout the two-year period are also given.</p>					
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